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NOTES AND COMMENTS.

Purchase of Pig-Iron by Analysis.

While the use of chemical analysis has made considerable progress among founders in this country of recent years, the practice of purchasing to analysis has not yet been generally established. In fact, under the conditions that exist here its general adoption is extremely difficult. In America the system appears to have made greater headway, and has considerable advantages if intelligently followed. Discussing the question recently before the American Foundrymen's Association, Mr. O. J. Abell remarked that as a result of the increasing practice of purchasing pig-iron by analysis rather than fracture, the process of buying off-grade iron largely—together with enough other iron of such analysis as may be required to yield the required cupola charge—which in its early stages was the device of the more clever, has become a common expedient. The foundryman, therefore, who is about to replenish his stock wisely surveys the situation, seeking where he may find iron, for example, that furnace A would be glad to move off its yard and which, happily, may combine with furnace B iron, likewise of uncertain saleability, to give just about what he desires."

"So far has dependence come to be placed upon analysis," says Mr. Abell, "that the problem of the iron melter has an even more flexible solution through the use of a wide variety of scrap. Mixtures are now being made from materials the use of which formerly would have constituted rankest heresy. The foundry—grey iron or malleable—whose operation is associated with that of machine or metal-working shops, finds that the use of scrap from these sources, representing a handsome profit as against the melting of corresponding weights of pig-iron, can be made to yield castings quite as good as have ever been made.

"In a large motor-car manufacturing plant almost all the sheet metal scrap is reclaimed, bundled and charged into the cupola up to 20 per cent. of the mixture, and very little distinction, if any, is made in the castings for which the resultant metal is used. A certain manufacturer of car wheels frequently is a buyer of off-grade iron running high in sulphur, and encounters no difficulty in securing excellent results with that iron in a mixture containing a proper quantity of open-hearth steel scrap.

"The willingness of the foundry to use iron of special analysis is not without its advantages to the pig-iron producer. Every merchant furnace sometimes accumulates off-grade iron, and iron also of irregular though possibly desirable character, because of a badly working furnace, and again when changing over from a run on one kind of iron to another, as from malleable to foundry. But instead of having so much off-grade iron, which must be sold at a sacrifice, it has become a logical measure to sort out a considerable proportion which alone, or in combination, may meet the specifications of a customer. In fact, certain furnaces have undertaken in this way to enhance their chances of securing business by supplying exact analyses with-

out reference to regular grading. The greater possible utility of all iron naturally has added to its value, and while special irons must still be sacrificed on a slow market, such iron, when the market is strong, can be marketed apparently on a basis of parity with iron of regular grading instead of being always at a discount. On the other hand, the freer use of scrap has curtailed the market for off-grade iron."

So far as British founders are concerned, pig-iron makers have in the past been very conservative in their willingness to accommodate advanced ideas, particularly as regards supplying iron to analysis, or even quoting the analysis of that supplied. But there has of late developed a tendency to meet the foundryman's desires to a greater extent, though too frequently the latter has not first possessed himself of that broad conception of the relation of analysis to requirements which is necessary for success. The strict analysis idea that was taken up by some when the foundry chemist first appeared can readily become a bugbear instead of a help.

The Carbon Question.

The foundryman and the research worker alike are often loth to depart from preconceived ideas, and this fact accounts for many scientific theories falling short in practical fulfilment, whereas a little modification in each would establish their common basis. The foundryman is still a long way from accepting the chemists' theory of mixing by analysis, as he finds that fracture affords something of a guide which ordinary analysis does not. The defect lies in the limitation of ordinary chemical analysis when taken apart from the fracture appearance of the metal. We have frequently, in the past, drawn attention to the importance of regarding, not only the carbon contents of a metal, but also the *particular nature of the graphite*, resulting from the conditions of the blast furnace in which it is made. Whether or not graphite in iron is subject to strictly alotropic modifications does not matter to the founder; but the fact remains that its nature may be distinctly dissimilar in two different irons. This fact was brought forward in our comments on a Paper by Mr. W. B. Parker (see F.T.J., April, 1913), and also in discussing the researches by Mr. E. Adamson at an earlier date (December, 1911). The suggestion that graphite in irons could possess more than one essential nature has been combated rather vigorously in some scientific circles, however, and in the face of works practice many have refused to consider that it could even possess more than one grade of refractoriness. It is therefore interesting to follow some comments on the subject in a Paper read last month before the Manchester Association of Engineers by Mr. E. L. Rhead, of the Manchester School of Technology. Discussing the strength and properties of castings, he says :—"All cases of kishy irons must not be attributed to the fall in temperature of the metal. There is every probability that in melting in the cupola some of the graphite is not re-dissolved by the iron, and the metal, as it runs from the cupola, contains free graphite which rises in the ladle. Such graphite interferes with the development of structure and gives rise to other difficulties, all of which tend to lower the strength of the casting. For example, they form solid attachments for gas which may form blowholes or gas films, and probably lead to formation of larger flakes than would otherwise be the case, as, by acting as nuclei, the rest of the graphite may be deposited on it much in the same way as solids are placed in crystallising liquids to receive the crystals formed. For these reasons probably test bars and castings run at high temperatures have greater strength than those run at lower temperatures."

Apart from Mr. Adamson's contentions, based on his own work, this is the first authoritative acknowledgment we have so far seen of the possibility of the *condition* of the graphite in the pig-iron (as distinct from its amount and the other constituents) having any influence on the final casting. If chemists and foundrymen alike will only acknowledge the fairly apparent fact that the graphite in a pig-iron may not always be perfectly dissolved during cupola melting, they will remove many of the difficulties at present on the way of practically applying analysis to the mixing of metals.

Pouring Temperatures.

Proceeding a little further with the development of this subject, we may again quote Mr. Rhead :—

"As to what is the correct temperature at which to pour a casting, obviously it is impossible to state any definite temperature that will apply to all cases, as regard must be paid to so many different factors; not only to the nature of the metal, but, among others, to the size of the casting, the length of time it will take to pour, the fluid contraction, and the final shrinkage. It may be laid down that the most suitable temperature for casting is that which will allow the mould to be completely filled with molten metal, which, when the mould is full, still retains all its constituents in completely fluid solution . . . It is not only unnecessary but inadvisable to heat the metal beyond that temperature, since the longer period of setting prolongs the period during which the casting is weak, gives opportunity for the formation of coarser graphite, and the formation and transference of the most fusible eutectic possible in the iron used, with the formation of shrink holes and local weakening where it has been withdrawn."

He further suggests that those castings are weakest in which, from any cause, the separation of iron-carbide or graphite precedes the proper development of crystallisation in the mass. In the many examples of strong iron that have come under his notice in which similar materials have yielded widely different results, those giving the higher figures have had this crystalline development, and those giving the lower figures have been confused, or in some cases almost striated, when microscopically examined.

From these considerations it would appear that for every type of metal and for every casting there is an ideal pouring temperature at which the slowness of the cooling shall not lead to the separation of coarse graphite with consequent loss of strength; and with this we agree. If, however, as an essential it be admitted that complete solubility of the constituents is necessary, the temperature must be raised to a point which will completely dissolve the most refractory graphite present, and that high temperature might well exceed the ideal temperature for some castings, so far as the necessary rapidity of cooling for the best structure is concerned. This brings us back to the contention that not only must regard be paid to the ordinary chemical constituents of the iron and to the proper pouring temperature, but the nature of the graphite (generally well indicated by the iron's fracture) must be considered; otherwise the presence of undissolved graphite, even at the best pouring temperature, will lead to accelerated precipitation of graphite and a disturbance of the best cooling conditions.

Chill Casting of Non-Ferrous Alloys.

At a meeting of the Birmingham Branch of the British Foundrymen's Association held on January 22, Mr. F. Johnson, M.Sc. (head of the Metallurgical Department of the Municipal Technical School), gave a lecture entitled "The Casting of Non-Ferrous Alloys in Chill Moulds." Mr. J. Shaw (Branch Vice-President), who presided, said that the subject was one of particular interest at the present time, when casting in chills was being adopted for automobile castings and to some extent for aeroplane castings.

Mr. JOHNSON, in introducing the subject, said that he thought that no apology for the chill-casting was needed. Under certain conditions the chill-casting could be rapidly produced if simple in shape or in the form of bar. The speed of production, however, could not compare with that of the sand-casting, and it was only in the case where the superior mechanical properties of the chill-casting were indispensable that it came up for consideration. Putting the matter briefly, the following were the advantages and disadvantages of the chill-casting:—(1) Better mechanical properties; not so much due to chilling action as to absence of pores. (2) Sand-moulding labour dispensed with. (3) Ease of extraction and re-preparation of mould. (4) Suitability for repetition work. (5) Saving of scrap and swarf as against bar metal. Some disadvantages were:—(1) Reduction of output unless organised for repetition work. (2) Inferiority of surface unless conditions are ideal, necessitating more machining. (3) Difficulty of coring intricate parts. (4) Initial cost of mould and slow deterioration in use.

The great advantage of chill-castings over sand-castings which strongly appealed to him was the marked superiority in mechanical properties possessed by the former. The common belief that the superiority was due to the "chilling" action of the mould producing rapidity of solidification and cooling required considerable modification.

Unlike iron-carbon alloys (Mr. Johnson continued). the brasses and bronzes do not possess an intensely hard constituent which is retained by rapid cooling. In the case of brass containing the Beta phase, relatively more of this strong constituent is probably retained by the rapid cooling of a chill-casting than by the slow cooling of a sand-casting. The improvement in mechanical properties due to this fact cannot be regarded as important. In the case of copper-tin alloys relatively more of the Delta phase would be retained in a chill-casting. There is, however, another consideration involved in rapidity of solidification, and that is introduced by the presence of gases in the molten metal. As is well known, such gases are less soluble the lower the temperature, and if thrown out of solution immediately prior to solidification they are trapped in the casting in the form of small bubbles. The more rapid the rate of solidification the less gas will be thrown out of solution, or, if any is thrown out, it will be trapped in the form of very minute bubbles. A slow rate of solidification, as in the case of the sand-casting, allows of coalescence of gas bubbles, formation of larger cavities, and consequently greater weakness.

A third and most important reason for the comparative weakness of sand-castings lies in the porosity of the metal due to cavities formed by minute bubbles of air and steam. It would appear, therefore, that the superiority of the chill-casting is due more to soundness than to any marked difference in constitution. The chill-casting does, however, exhibit a closer grain, the crystals being much smaller than the crystals in a sand-casting of similar composition.

Material and Design of Moulds.

The three materials which suggest themselves as suitable for chill moulds are grey cast iron, steel, and malleable cast iron.

The author has used the two former and found them satisfactory. Cast-iron moulds are more easily produced, and should be made with a generous allowance for machining to the exact dimensions required for the production of a casting, which itself must be on the large side to allow for the removal of surface defects by machining. The thickness of the walls of the mould depends upon its size; for small castings the walls need not be more than 2 in. thick. Thin moulds are more liable to fracture when roughly handled; the thicker the mould the quicker the abstraction of heat from the casting.

Steel moulds may be thinner, and it is possible, in the case of single small moulds, to clamp together the split halves of a piece of round bar steel and machine out the internal shape of the mould in the lathe.

Whether the parts of the mould form vertical or horizontal joints, strong clamps should be provided of a simple type which lends itself to rapid tightening and loosening. A form of clamp favoured by the author acts on the same principle as the ordinary foundry crucible tongs, the tightening being effected by forcing a small steel link over the handles. A simple ring of wrought iron, with the free ends drilled to take a small bolt and butterfly nut, is effective. A cast ring, drilled and tapped to take a small eye-bolt, is also satisfactory and simply handled. For square or rectangular moulds a rectangular ring fastened with eye-bolt or wedges may be used. The disadvantage of using loose wedges lies in the inconvenience arising if they are not to hand when wanted.

If the parts of the mould are hinged together the hinges should work smoothly and easily. Dowell-pins may be used to obtain correction of alignment of the parts, and may serve also to hold them together when passed straight through the corresponding holes and held tightly by nuts or keys. The mould parts should be fitted with suitable handles to facilitate handling when removing the casting; these may either be cast or screwed in.

Strict attention should be paid to the venting of the joints so that there may be free egress for air from the mould. If there is insufficient provision for escape of air the casting will be either spongy or its surface spoilt by the presence of air-pockets. By cutting thin shallow grooves across the surfaces of the joints these troubles may be obviated. One method of venting chill moulds was described by H. G. Barrett in illustration of his remarks at a London branch meeting of the British Foundrymen's Association on April 23, 1915. (See FOUNDRY TRADE JOURNAL, June, 1915.)

The composition of the iron for cast-iron moulds

is a matter of considerable importance. The iron should be tough and close-grained and, it is needless to add, free from blowholes. Strength and toughness are very important, as the moulds have to withstand rough handling. W. J. May recommends the production of moulds with such a good finish that machining will be unnecessary. He instances the following composition of an iron successfully used for moulds:—Combined carbon, 0.84 per cent.; graphitic carbon, 2.76 per cent.; silicon, 2.02 per cent.; sulphur, 0.07 per cent.; phosphorus, 0.89 per cent.; manganese, 0.29 per cent. The high phosphoric content is justified by May on the ground that the fluidity which it confers enables moulds of sharper outlines to be produced. He also states that an iron high in combined carbon would probably "grow" and become deformed under repeated heating.

The author considers that from the point of view of the user a high phosphoric content is inadmissible. The phosphide eutectic has a very low fusing point, and the repeated contact of molten copper alloys has an erosive effect which rapidly spoils the surface of the mould. Cast-iron moulds containing phosphorus and used for the casting of copper cylinders have, in the author's experience, rapidly deteriorated and caused much trouble in the extraction of the castings, owing to the badly eroded surfaces causing "sticking." The presence of phosphorus, moreover, increases brittleness and thus impairs the resistance of the mould to the effects of rough handling. A cast iron with low phosphoric content is, therefore, a desideratum, for, even if sharp outlines are not obtained, the surface can be machined, and, thus prepared, allows of the production of castings cleaner and truer to size. It must also be remembered that not every iron-moulder can produce castings with highly-finished surfaces.

Dressing of Moulds.

For the protection of the mould surface and to facilitate the extraction of the casting, a dressing should be applied to the mould. The author has tried numerous dressings, such as seal oil, lard oil, linseed oil, Russan tallow, etc., mixed with charcoal or plumbago. Seal oil liberally charged with fine plumbago appears to be as satisfactory as anything. It should be warmed and liberally applied, well rubbed on to the mould surface, and *all excess* removed before pouring. Considerably more disadvantage than advantage will accrue from leaving an excess of the oily dressing in the mould.

In contact with the molten metal, partial distillation takes place with the production of gaseous hydrocarbons which are trapped in the casting before they can gain egress from the mould. Just sufficient dressing is required to form a gaseous envelope between the casting and the mould in order to give a clean surface to the former, to facilitate its extraction, and to protect the surface of the mould. If carbonaceous dressings are considered undesirable, an emulsion of bone ash and water applied with a brush to the warm surface of the mould should prove efficacious. The water is rapidly evaporated by the heat of the mould.

A very uniform and satisfactory dressing may be applied by holding the mould-surfaces over a smoky flame, that from burning resin being very effective, if troublesome. The warming of the mould prior to pouring is, indeed, important, owing to the "blowing" action of rust or moisture.

Cores.

The composition and arrangement of cores presents some difficulty. After using sand cores the author resorted to the use of tapered steel cores and found them more satisfactory. The careful alignment of sand cores in iron moulds presents difficulties, whereas steel cores may be much more accurately fitted; they are permanent, thus effecting economy in labour, may be easily removed, and leave a cleaner, smoother surface on the casting.

In a short paper on "Casting Brass in Chill Moulds," read in April, 1915, before the British Foundrymen's Association, Alex. Hayes recommends the use of dry-sand cores of a "light hard nature which disintegrate under the heat and pressure of the metal immediately after solidification." The disintegration of the core, he said, depended upon the nature of the binder used with silica sand. Some binders left an open structure after drying and disintegrated very well under the heat of the metal. Linseed oil is used successfully as a binder.

Gating.

The provision of a satisfactory "gate" for chill moulds has introduced difficulties. Owing to the rapid chilling effect of iron, no marked constriction of space at the junction of the head with the casting can be allowed, as setting of the metal is likely to take place here before the casting has solidified. The solid neck thus formed prevents the remaining molten metal in the head from fulfilling its true function, viz.: that of feeding the spaces in the casting caused by shrinkage. By carefully diminishing the rate of pouring as the mould fills this difficulty may be partly overcome, but even with this precaution a considerable amount of metal is required for the head when formed in the mould itself. It occurred to the author that a very much smaller head would suffice if it could be kept molten until after the solidification of the casting. To effect this, the gate was made in sand in a detachable ring placed on top of the mould and kept firmly in position while pouring. The lower thermal conductivity of the sand enabled a very small head to do all the feeding. A small riser was also added with the object of securing free egress of gas and air from the mould. An examination of the small heads (see Fig. 1) proved that the feeding was satisfactory. In one experiment the weight of the head represented only 8 per cent. of the total weight of metal used. This method also has the advantage of securing a more effective elimination of dross, air, and gas. Particles of dross on the surface of the rising metal in the mould are held in the solid skin which forms immediately the metal touches the iron "roof" of the mould. When this roof is of sand the abstraction of heat is less rapid, and opportunity is thus afforded for the particles of dross to be carried upward into the head. Gas and air also find outlet through the interstices in the sand.

Surface Condition of Casting.

The elimination of dross from the surfaces of the casting has proved to be the greatest difficulty which has confronted the author in producing brass castings in chill moulds. Various devices have been adopted to overcome this difficulty.

The position of the mould has some bearing upon the problem. Taking, for instance, an article of cylindrical shape, if placed with its main axis in a vertical position, the ascending dross will have to change its direction from vertical to horizontal when the top of the mould is reached, and the chances of its complete elimination are small. On the other hand, if placed in a position with the main axis at an angle of 45 degrees to the

vertical, the horizontal surface of the molten metal will never strike a horizontal surface of the mould, and particles of dross will never have to choose the only alternative to imprisonment in the mould—namely, that of traversing a horizontal path towards the outlet. Similarly, a mould should be so made that any projecting portion of the casting is at the top and not at the bottom, in which latter case the overhanging portions of the mould encourage the imprisonment of dross (see Fig. 2).

The best possible way to secure castings with smooth, clean surfaces is to prevent ingress of all dross and oxide to the mould.

A suitable flux which will dissolve zinc oxide is very useful, but zinc oxide is produced even in the stream of molten metal entering the mould, as also is aluminium oxide if aluminium be present. The addition of aluminium to copper-zinc alloys has the effect of checking oxidation of the zinc by reason of the formation of a tough, tenacious film of aluminium oxide on the surface of the molten metal. This film protects the underlying metal from oxidation, and incidentally enables a clearer view of the contents of the crucible to be obtained, the formation of obscuring fumes of zinc oxide being effectively obviated. No other deoxidiser which the author has used has such a marked influence in this respect. Neither flux nor deoxidiser, however, will in practice secure a clean stream of metal free from dross, nor will the most careful skimming.

In order to prove that dross was the cause of rough surfaces, the author made the following experiment:—A graphite crucible was pierced at the bottom with a ¼-in. hole, and a ¼-in. arc-lamp carbon was used to plug up the hole and act as a stopper. This crucible was heated to a red heat and placed in position over the gate of the mould. Molten metal was poured into the hot crucible, and, when it was reasonably certain that all the dross had risen to the surface, the stopper was removed and the clean metal from the bottom allowed to teem into the mould. The author was able by this means to produce castings quite free from surface imperfections.

Bottom Running.

To arrange for bottom-running in chill moulds is extremely difficult owing to the danger of freezing of the metal at any point of flow where there is a constriction of sectional area. To overcome this difficulty the author proposed to arrange gate and runners in sand, each runner supplying a chill mould. In this way the necessary head of metal was obtained for efficient feeding, a small riser to each chill mould allowing of escape of gas, air, and dross. Bottom-running has the advantage that hot metal is continually coming up and pushing in front of it the floating dross, and, as solidification cannot commence until the mould is full, every facility is afforded for the escape of air and gases. (See Fig. 3). Clean castings were successfully produced in this way.

Composition of Alloys for Chill-Casting.

The problem which the author was first called upon to face was how to produce in the form of a casting an alloy which would give as good results in the manufacture of fuses and meet the same stringent specifications for mechanical tests as some of the highest qualities of rolled brass bar. The Government specification for "A" metal, to which reference is here made, is as follows:—Yield point, 20 tons per sq. in.; maximum stress, 30 tons per sq. in.; elongation, 20 per cent.

In order that risks of premature explosion of shells may be avoided, the presence of lead was prohibited except in very minute proportions, namely, 0.01 per cent. Although this was afterwards altered to 0.10 per cent., it is obvious that there was no hope of supplying the huge demand created in the early days of 1915 from the existing stocks of lead-free brass and zinc.

There was nothing for it but to fall back upon the commoner grades of metal and to suitably and effectively coat them with a metal or substance which contained no such injurious element as lead. It is the ready formation of lead picrate which, owing to its explosive action, has to be circumvented at all costs.

The presence of lead in brass has, however, two other important effects, one good and the other bad, namely, the improvement in the machining properties and the impairment of the mechanical properties. In order to emphasise the superiority in mechanical properties of chill-castings over sand-castings it will suffice to cite a few instances from recent literature:—

TABLE I.

Composition	Condition	Yield Pt. tons per sq. in.	Breaking Stress tons per sq. in.	Elongation %
Cu. 95, Al. 5	Sand-cast	4.3	18.1	75
	Chill-cast	7.1	18.1	60.5
Cu. 90, Al.10	Sand-cast	11.3	31.7	21.7
	Chill-cast	12.4	36.93	30.5
Cu. 88, Al. 10, Mn. 2	Sand-cast	13.2	34.44	24.0
	Chill-cast	16.8	37.00	25.0
Cu. 56 % Zn. 41 „ Fe. 1.5 „ Sn. 0.9 „ Al. 0.45 „ Mn. 0.15 „	Sand-cast		33.4	20.0
	Chill-cast		38.4	25.0

After a brief survey of the common metals available, of the extent of the demand, and of the class of labour available, the author decided that the copper-zinc alloys offered the most promising field for the brief research possible, owing to the large sources of supply of the component metals, to their comparative cheapness, and to the familiarity of the local brass-caster with them. It was immediately realised that no alloy of copper and zinc without the addition of some other metal could give the desired results.

Attention was therefore given to the so-called manganese bronzes, which are copper-zinc alloys to which other metals such as manganese, iron, tin, and aluminium are added in various proportions. The following composition is given by Gillett:—Copper, 56.0 per cent.; zinc, 41.0 per cent.; iron, 1.5 per cent.; tin, 0.9 per cent.; aluminium, 0.45 per cent.; manganese, 0.15 per cent.

The results of mechanical tests on a chill-cast alloy of this composition is given as follows:—Maximum breaking stress, 38.4 tons per sq. in.; elongation, 18.0 per cent. minimum, 25.0 per cent. maximum.

An alloy of this type modified in composition to ensure percentage elongation of over 20 per cent.

was made up and tested in the form of a ¾-in. sq. chill-cast bar. The composition of this alloy by analysis was as follows:—Copper, 58.64; zinc, 38.9; tin, 1.053; manganese, 0.926; aluminium, 0.162; lead, 0.107; iron, 0,212. (See alloy CH_1, Table II).

The results of mechanical tests were:—Yield point, 17.25 tons per sq. in.; maximum stress, 30.4 tons per sq. in.; elongation, 22.5 per cent. on 2 in. ($L=4\sqrt{\text{area}}$).

It will be seen from the test figures that this, the first, attempt failed only in yield point, and by a very little, to meet the specification for "A" metal. Lewis makes the following recommendation as to composition:—Copper, 50 to 58 per cent. (maximum); tin, 1.3 per cent. (maximum); manganese, 2.0 per cent.; iron, 0.5 per cent.; aluminium, 0.25 per cent. (maximum).

It seemed that a solution of the problem was not to be sought by adopting any alloy of this type, owing to the narrow margin which the comparatively soft alloy CH_1 possessed in percentage elongation.

The following composition has been recommended for shrapnel sockets to be made in chill-moulds:—Copper, 56.0 per cent.; manganese copper, 2.0 per cent.; zinc, 41.0 per cent.; tin, 0.5 per cent.; aluminium, 0.5 per cent. In Table II. are given the approximate compositions and test results of other alloys of an exploratory character.

The results obtained from alloy CH_2, Table II., suggested that by further stiffening the yield point and maximum stress might be considerably raised, without lowering the elongation to 20 per cent. This chill-casting, having 40 per cent. elongation, provided a big reserve of ductility. Knowing the limitations of tin, and desiring to avoid so expensive an ingredient; knowing also the detrimental action of large additions of aluminium on the surface condition of chill-casting, the author determined to omit the former and add only so much of the latter as was required to give fluidity. This small quantity of aluminium has a remarkable influence on the fluidity and surface of these alloys, as is exemplified in alloys 2A and 2C. The desired increase in strength was hoped for from larger additions of manganese and iron.

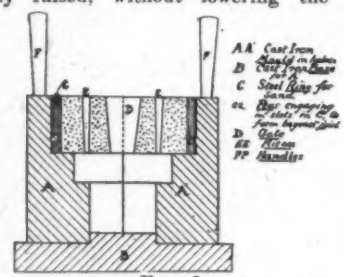


FIG. 1.

An important modification of the specification had been introduced at this point, B metal having been substituted for A metal, and the lead restriction had been eased. The specification for B metal is:—Yield point, 12.0 tons per sq. in.; max. stress, 20.0 tons per sq. in.; elongation, 30.0 per cent. on 2 in. ($L=4\sqrt{\text{area}}$).

In Table III. are given the results of experiments to produce a chill-casting of B quality.

Whilst much work remains to be done to ascertain the individual influence of each metal, it nevertheless seems fairly certain that manganese has only a mild influence, whilst that of iron is more intense. These two metals together give the brass a paler hue, but also consolidate the structure, giving fineness of grain and increased toughness. The micrographs show how the crystalline structure is altered, a much finer structure resulting from the addition of manganese.

The behaviour of these alloys under stress is quite different from that of the pure copper-zinc alloy, which shows the external surface flow-lines usually associated with cast brasses. The surface of the stressed bars J2A, J2B and J2C is smooth, resembling that of cold-drawn rod. The fracture also is silky, and shows a tendency to cup. The surfaces of these alloys, particularly J2A, behave exactly like drawn rod.

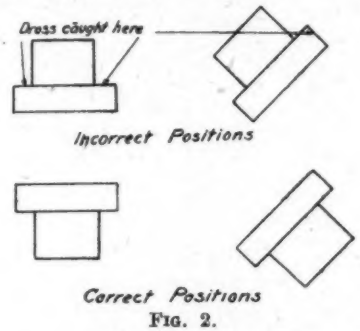


FIG. 2.

The presence of 1 per cent. of lead does not affect these features, whilst improvement in machining properties is obtained, and the cost of the alloy reduced. The risks which would result from its contact with picric acid are obviated by other means, that is tinning or nickel-plating.

The small addition of aluminium, whilst adding to the strength, produces an extraordinary improvement in casting qualities. An examination of the surfaces of the two castings reveals the superiority of surface produced by aluminium. Without aluminium the alloy is pasty and runs sluggishly, the casting having a dull surface and not exhibiting a clean, sharp impression of the mould. With aluminium the alloy becomes enlivened, has greater fluidity, and produces a sharper casting with a very smooth surface. These effects must be attributable to the strong deoxidising power of aluminium, which removes the viscosity due to insoluble oxides (present in a finely-divided state in suspension) by reducing them to the metallic state.

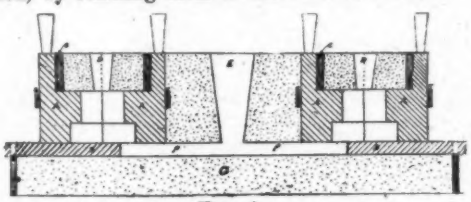


FIG. 3.

To recapitulate:—(1) Manganese and iron improve the mechanical properties of these brasses.

(2) Lead improves the machining properties.

(3) Aluminium improves the strength and casting properties. It is important, however, to prevent the entry of dross into the mould.

The influence of iron on brass has not been studied in any detail. Hofman states that up to 3 per cent. Fe. strengthens and hardens "brass," increases the malleability when hot and the resistance to corrosion.

The author concluded with a reference to the rapidly increasing production of fuse-plugs, sockets, fuse-bodies, etc., by means of presses or stamps which forge the cast blank into rough shape. In

this way the mechanical properties are improved, and, where the shape of the article is complex, a good deal of cutting away is avoided.

Discussion.

The CHAIRMAN remarked that the research dealt only with one particular class of chill-casting, but it evidently provided a basis for practical experiment by manufacturers and others who were interested in fuse work. He had had no personal experience of such work, and the little he knew about it had come from the reading of the papers which had been published. Mr. Norton, before the American Institute of Metals, in 1914, dealt with chill-castings in aluminium alloys for automobile work, and stated that in France, except for oil-boxes, which were very complicated, the cores as far as possible were put in the chills, and there was no sand at all about it.

Mr. H. L. REASON remarked that stamping, pressing, and extrusion processes had a wonderfully improving effect on the tensile and elongation of copper-zinc alloys which contained sufficient lead to render machining easy. The chilling effect on copper alloys also gave the same good results. had been using chill-cast bars. This was for the "C" test. Some they cast for themselves, and others they got cast for them. In both cases they found at times the bars gave awful trouble in the machining, and therefore they told the casters to put in about 2 per cent. of lead. They found even then that if the man succeeded in burning out enough of the spelter before he poured, a bar was got so hard that it would not machine at all. They found that the raising of the copper percentage to about 61 completely destroyed the machining qualities. By adding 2 to 3 per cent. of spelter they got over all the difficulty, as it left a sufficient margin for melting loss. There was another point in their experience with chill-casting. He did not know how far it applied to small light castings, but with bars they found that although the lead was present in the swarf or scrap that was melted, and was apparently very intimately mixed, yet when the mixture was melted the lead in the bars occasionally seemed to segregate and come away from the mixture. The lead came out, and they found the chill-cast bars would crack, particularly towards the bottom of the mould. The lead came away in grey-black patches where the cracks

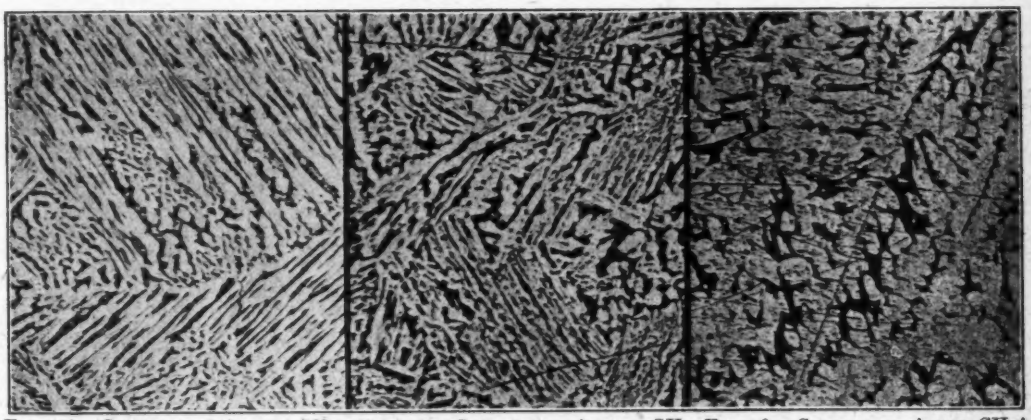


FIG. 4.—CHILL-CAST ALLOY CH_9 (TABLE II.) MAG. × 100 V. COARSELY CRYSTALLINE COMPARED WITH FIG. 5.

FIG. 5.—CHILL-CAST ALLOY CH_9 (TABLE II.) MAG. × 100 V. NOT AS COARSELY CRYSTALLINE AS FIG. 4.

FIG. 6.—CHILL-CAST ALLOY CH_9A. (TABLE III.). MAG. × 100 V. VERY COARSELY CRYSTALLINE COMPARED WITH FIG. 7.

There was a big field for exploration in ascertaining what could be done with regard to chill-castings. If Mr. Johnson would continue his investigation and research work, particularly on commercial alloys, such as brasses containing 60 per cent., 62½ per cent., 65 per cent., 67½ per cent., and 70 per cent of copper, and bronzes containing 85 per cent., 87½ per cent., and 90 per cent. of copper, with different percentages of zinc, tin, lead, manganese, iron, aluminium, phosphorus, etc., this would be a boon to the brassfounding industry. In making castings in chills, the iron moulds must be made from good iron, low in phosphorus. Thickness of chill was also important when making solid castings; the difficulty was to overcome the sinking in the centre.

Mr. STANLEY EVERED asked Mr. Johnson about the effect of lead in different alloys, and whether he could work out the effect of lead on the mechanical properties both from the machining point of view and with regard to the physical tests. At his works they started making fuses from the bar. Afterwards, they found they could do better by using drop forgings, and while they were waiting to get going with drop forgings they occurred. Of course, cracks were got occasionally in all bars cast for rolling purposes, but not of the same character as in this case.

Mr. H. PEMBERTON, with regard to the rough surfaces of the permanent moulds, said it would be very expensive in many cases to machine all these moulds, owing to the intricacies of the castings required. For some of the castings Mr. Johnson had shown, for instance, an adaptor and a fuse body, the moulds could be machined up, but it would not pay to make the milling cutters for that purpose unless some thousands of castings had to be made. With regard to clamping up the moulds, he thought that possibly a hook-and-eye arrangement, similar to that used for core-boxes, would answer the purpose better than the tongs clamp suggested by Mr. Johnson. For preventing sponginess of surface it was essential that small vent-holes should be drilled at various points in the chill where gases were likely to be trapped, especially if the faces of the chill moulds were machined. As to the composition of the iron used in making the moulds, he thought Mr. Johnson had given them an iron with too high silicon and too high total carbon. The percentages named

were too high to allow the moulds to stand for any length of time if used for casting non-ferrous metals. According to Professor Carpenter the silicon should be lower, and this would certainly give better results with regard to the life of the mould. Mr. Johnson had spoken about dressing the moulds with various kinds of oil, but he would like to ask whether Mr. Johnson had tried a coating of plumbago and salt. That, he thought, would be found very effective, and there would not be so much gas arising from it as there was from carbonaceous oils. Blacking a mould with smoke by holding it over a flame might be all right in the laboratory, but was not practicable under ordinary working conditions. He would like to ask Mr. Johnson whether he found much difficulty in getting out the steel cores after casting. It appeared to him that owing to the contraction of the non-ferrous alloy there would be a great deal of difficulty unless the steel were coated with something that would come off. With regard to running the metal into the mould, Mr. Johnson ran it from the top through a sand-runner, but the speaker was inclined to think that the greatest mistake Mr. Johnson had made. With such alloys, having high percentages of zinc, if Mr. Johnson had run the metal in from the bottom, while still retaining the feeding-head made of the same material as at present, he would probably have done much better in preventing the castings having a rough surface. The whole secret of the difference between success and failure with that class of castings lay in running from the bottom instead of from the top, for in this way one could prevent zinc oxide or any other impurity from getting to any part of the castings, and allow the free metal to rise into the head, while keeping the same form of head as Mr. Johnson had used. He quite appreciated Mr. Johnson's point, that in running the casting from the top, as he had done, he had been aiming at getting the hottest metal to feed the casting at the top, and that by running from the bottom one would get the hottest metal at the bottom when it was wanted at the top owing to the segregation. But if Mr. Johnson would keep the riser head made of sand, the same as he had it now, he would find no difficulty in regard to segregation. A great difficulty had been experienced in casting manganese bronze, especially with very unequal thicknesses; for instance, when there was a ½-inch section and a boss of 2 in. or 3 in. He was speaking of casting in sand, but in the bottom of the mould, where one could not get a riser on it, it was essential to have a chill. How would Mr. Johnson proportion the thickness of the chill in a case of that kind? For instance, if he was going to cast in a chill mould a casting with one section 2 in. in diameter, and another section 3 in. diameter, what difference would he make in the thickness of the iron in the corresponding parts of the mould? If the mould were of one thickness throughout he would not get the proper effect of the chill, because the one part would solidify more quickly than the other. Dross on the surface of the casting could be prevented by running from the bottom. The great trouble in running from the top was to prevent what were called cold shots, which were due to the zinc segregation getting to the side of the mould. What Mr. Johnson said about pouring from the bottom of a crucible was very interesting, but the speaker doubted the practicability of this in the foundry. Someone spoke about casting 88-10-2 alloys. It was a most difficult alloy to cast, and he understood that it was hard to machine, but not if one went the right way about it. When one talked about it being hard to machine, it was the maker of the tool steel to whom the complaint should be made, for it was not the fault of the alloy at all. In attempting to cast this alloy they should add another 1½ lbs. of zinc to commence with, and then they would get the test and would also get a casting which could be machined. The trouble came from the volatilisation of the zinc, which resulted in the formation of particles of oxide of a greenish colour.

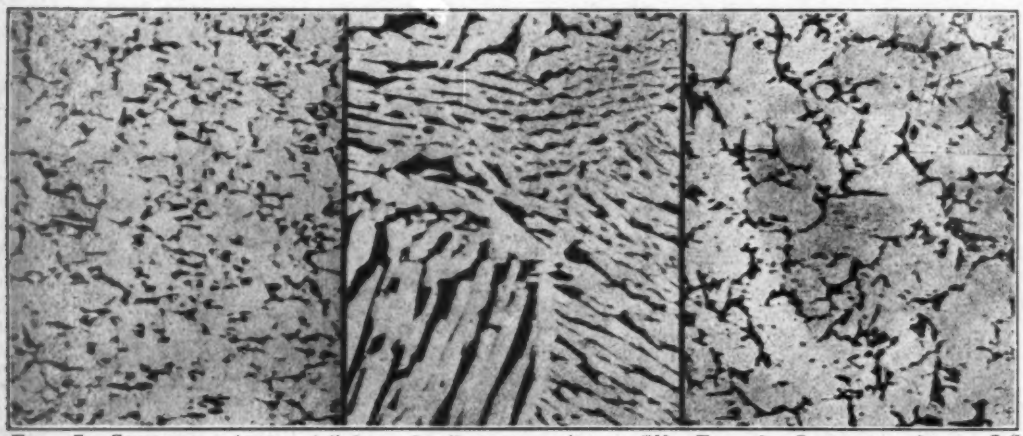


FIG. 7.—CHILL-CAST ALLOY J_2C (TABLE III.). MAG. × 100 V. MUCH MORE FINELY CRYSTALLINE THAN FIG. 6. SHOWS LESS BETA, ALTHOUGH LOWER IN COPPER.

FIG. 8.—CHILL-CAST ALLOY CH_2. MAG. × 200 V. SAME AS IN FIG. 5.

FIG. 9.—CHILL-CAST ALLOY J_2C. MAG. × 200 V. SAME AS IN FIG. 7.

Mr. F. G. CHAMBERS (Derby) asked Mr. Johnson, with reference to the manganese series, in what form was the manganese added? He would also like to ask whether the iron was added as an alloy or as iron alone. With regard to Mr. Pemberton's remarks as to 88-10-2, when the alloy was dealt with correctly there was no difficulty whatever in getting the desired test results. In view of the tremendous amount of work that had recently fallen upon brassfounders in dealing with these high specifications, there ought to be some standard form of test-bar. In some cases the test-bar was cast on the casting, and in others special

test-bars were cast. There should be a specified standard class of test-bar for non-ferrous alloys. One of the most interesting features of Mr. Johnson's figures was the high manganese and its effect upon elongation. He thought the figures in the lower part of the table showed that the alloys they dealt with, although intended for the "G" test, were adaptable to the "B" class requirements. Manganese and aluminium were the two controlling factors, and Mr. Johnson's remarks with regard to the running of the adaptor casting were very instructive, especially with regard to the scum. His opinion was that if the quantity of aluminium was kept low there was very little difficulty with regard to the scum. He noticed Mr. Johnson's chills were all through of one thickness, but the adaptor had two distinct diameters, and it appeared to him that this was one cause of the failure in casting the adaptor. The thickness of the chill should vary with the diameters in the contour of the body. Otherwise there would be a varying chill, which was inimical to the production of a good, sound, homogeneous casting. He would prefer the chill mentioned by Mr. Johnson as made from bar steel.

Mr. PEMBERTON: Do you wish to infer that you can get the "B" test with that series?

Mr. CHAMBERS: Certainly. With reference to the figures at the bottom of the table (Mr. Chambers continued), he noticed the content of iron, but he thought that might almost be considered as foreign matter. The aluminium was given as 0.35 per cent. and the lead 0.96 per cent.; the copper 59.1 per cent.; and the zinc 38.75 per cent. No. 10 gave 20 to 25 tons tensile and 25 to 30 per cent. elongation.

Mr. PEMBERTON: That is not the "B" test.

Mr. CHAMBERS: I am speaking of the "G" test—the specification of bronze mentioned. Commercial zinc might contain other matter, from 0.5 or less, from 0.37 up to as much as 0.5. That was a very great factor in making a mixture. People might be working to a certain lead content and actually putting in lead in the specified proportion when the zinc already contained that amount or probably more. Brassfounders often made a mistake in this way. They should give more attention to the proper analysis of their alloys.

Mr. E. H. BROUGHALL (Coventry) took exception to the term "chill." The Association, he said, had been for a long time trying to get rid of that word, and it certainly should not be used in connection with non-ferrous metals. He thought the lecturer had given too much importance to the composition of the metal for iron moulds. His own experience was that any good machinery iron would do for this purpose. He could assure them that iron moulds made from ordinary grey iron were still in use at Edgwick Foundry, although many thousands of castings had been made in them. With regard to the production of fuse-body castings, as far as he knew the latest method was to make a sand casting and then compress it to 15 per cent. less than its original bulk. By this method it was quite easy to conform to the War Office specifications in regard to tensile tests. Two thousand such castings per day could easily be produced from one moulding machine. With regard to coring these small castings, this was not at all necessary if the castings were machined with a modern tool outfit. The small loss of metal through making the castings solid was easily compensated for by quicker machining times. Mr. Reason had mentioned the stringent tests laid down by the War Office for such castings, and the effect this had had on the brass-foundry trade. He would suggest to Mr. Reason, however, that they should be very thankful to the War Office indeed for insisting on these tests, as it had been the means of compelling brassfounders who had been working on old-fashioned lines to bring themselves more up to date.

Mr. F. J. EMBLEM (Birmingham) said that Mr. Johnson seemed to regard chill moulds as being necessary to get the required mechanical results to meet "B" specification, but the mechanical results were already being obtained from sand-castings. For instance, they could get 16 to 18 tons yield, from 32 to 36 tons tensile, and 20 to 30 per cent. elongation in sand-castings with manganese bronze. In his experience, casting in chills undoubtedly raised the tensile strength, but lowered the elongation, and he was rather surprised to observe that in most of the results tabulated Mr. Johnson had obtained a higher elongation on the chill-cast metal than on the sand-cast. With reference to 88-10-2 alloy, as the test required was quite easily obtained in sand moulds there seemed to be no reason why this should be cast in iron moulds and thereby cause trouble in the machine shop.

Mr. A. HARLEY (Coventry) said it should be remembered that the lecturer had rather limited resources at his command for carrying out a practical research on manufacturing methods. In this respect many private firms provided much better facilities. Mr. Broughall had already mentioned the method of improving the physical quality of metal by compression. He (the speaker) thought it was fairly obvious that it was a matter of extreme difficulty to obtain the physical tests aimed at by ordinary means. This method of applying pressure was actually in use in certain special lines of work and was giving very good results. In making tensile tests it was quite possible to have a torsional stress operating which would vitiate the result. The method of gripping test pieces required more attention.

Mr. JOHNSON, in reply, said that the first speaker, Mr. Reason, was inclined to think that there was no hope of getting what was wanted from a sand-casting, whilst another gentleman maintained that a sand-casting would give all that was required. From his own experiments, and from tests of numerous commercial alloys carried out by him, he believed that for mechanical properties the sand-casting was not a serious competitor of the chill-casting. Mr. Evered had spoken of the desirability of investigations to determine in a scientific way the effect of lead in various alloys. That, of course, would be done either by himself or by somebody else, he hoped before long; he also hoped that the effect of lead on the machining properties would be investigated. The other remarks of Mr. Evered were of very great interest. One point Mr. Evered mentioned was the low value of the scrap of alloys of this type. He (Mr. Johnson) had not gone into that matter, but he knew very well that scrap from these alloys was not a very desirable material from the brass-founder's point of view. The matter was important and worth further consideration. There was no doubt that lead existed in alloys rich in copper, only mechanically mixed and did not go into solution, and that if present in any quantity beyond a small percentage would segregate. The larger the quantity and the larger the casting the greater the tendency to segregation. With regard to the criticism that the silicon was too high in the composition of the iron to which he referred, he would point out that he did not recommend that iron. The composition had been recom-

mended by a writer on the subject of the manufacture of permanent moulds, and was mentioned as this writer's recommendation. Not everything in the paper was necessarily to be taken as his own recommendation, nor did he necessarily support the recommendation of other workers. With regard to the dressing of the mould, he had not tried plumbago and salt. Was it salt dissolved in water? (Mr. PEMBERTON: Yes.) He saw no reason why this mixture should not make a good dressing. As to smoking the moulds, he simply gave it as someone else's recommendation; he had not tried it himself. Mr. Pemberton favoured bottom-running, but this involved the use of a very considerable quantity of metal, and that was why it was tried in only one case. At the time the experiments were made metal was very scarce, and every ounce counted. As to the proportion of the thickness of the chill to the thickness of the casting, he had not gone into that, but he thought it could be worked out quite easily. Mr. Pemberton poured scorn upon the idea of teeming from the bottom of a crucible. All he would say in reply was that much of the detail in the paper was simply historical; it was a record of attempts to find out the causes of trouble, and the tapping of metal from a crucible at the bottom was simply an improvised arrangement to prove whether dross was the cause of the trouble or not. Many statements in the paper represented those things which one had to carry out in the course of an investigation, and which were never expected to come into permanent operation. In reply to Mr. Chambers's question as to the form in which the manganese and iron were added to the alloys, in most of the alloys a copper-ferro-manganese alloy was used. In others, in which the iron was high, he used ferro-zinc or ferro-copper. To attempt to introduce iron in the metallic form into these alloys was certainly not advisable. As to the desirability of a specified form of test-bar, Mr. Gillett, who was engaged upon research work in the United States, dealt with the matter in papers recently read before the American Institute of Metals. With regard to the shape of the castings, some were of two diameters. One object in making them so was to reduce machining and production of swarf. Mr. Chambers also referred to the various grades of zinc which were offered to the brassfounder. The brassfounder in this case ought to have somebody to advise him as to the analysis of the material. Otherwise he would never be certain of his mixtures. One of the most important features of the present state of affairs was the lack of expert knowledge in many of the firms which had taken up this munition work. In criticising the paper, it should be borne in mind what the condition of things was when the investigations were commenced. Certain firms were asked to turn out these materials, but they had no machines; they had no knowledge whatever of the meaning of physical and mechanical requirements, and they did not know which way to turn. He did not recommend the making of these things as chill-castings if the required results could be obtained in other and more expeditious ways. All he had told them was that he had attempted to get certain results, and he thought he had been able to point out the limitations of the method. If he said he made certain attempts, and succeeded or failed, he did not mean that he recommended manufacturers to carry out their work on these lines. He had already noted the advisability of investigating the properties of alloys under compression. Many alloys, he believed, would reveal most interesting points if examined in that condition.

A hearty vote of thanks to the lecturer concluded the meeting.

TABLE II.—*Chill Castings.*

Composition.								Casting Qualities.		Mechanical Properties.					
No.	Cu.	Zn.	Mn.	Fe.	Sn.	Al.		Behaviour in pouring.	Surface Condition of Casting.	Government Quality.	Yield Pt. tons per square in.	Maximum Breaking Stress tons per sq. in.	Elongation % $L = 4\sqrt{\text{area}}$	Appearance of Surface of Stressed Portion.	Appearance of Fracture.
CH1.	58.64	38.9	0.926	0.212	nil.	0.162	Pb. 0.107	Fluid	Smooth	G Yield 8 tns □" Break 20 " Elongn. 20 %	17.25	30.4	22.5	Wavy; shewing marked evidence of strain.	Deep yellow; crystalline.
CH2.	60.73	37.2	1.7	0.3	nil.	nil.	—	R'th'r pasty	Rough	G	11.7	25.4	40.0	Wavy	Pale yellow; silky.
CH3.	62.21	34.7	2.5	0.5	nil.	nil.	P. 0.02	Ditto	Ditto	G	9.8	20.8	32.0	Ditto	Ditto.
CH6.	61.84	34.66	3.43	0.28	nil.	nil.	Ni. 0.7	Ditto	Rough spongy casting	G	9.0	21 4	38.0	Ditto	Ditto.
CH7.	60.0	33.0	3.25	0.75	2.0	1.0	—	Fluid	Smooth	—	13.0	20.6	6.0	Smooth	Granular; small blow-holes present
CH8.	56.91	37.31	2.48	0.2	1.67	0.26	Pb. 1.16	Fluid	Smooth	—	25.3	31.8	7.5	Slightly wavy	Deep yellow; crystalline
CH9.	59.92	39.0	nil.	Trace	nil.	nil.	1.0	Fluid	Smooth	G	9.06	24.1	41.0	Wavy	Full buff yellow; dull.

N.B.—Of the above alloys, Alloy CH1 is the nearest approach to "A" Metal in mechanical properties. It is probable that between this composition and that of CH8 an alloy could be found which would meet the requirements for "A" Metal in the form of a chill casting. Alloy CH2 very nearly meets the requirements for "B" Metal. Alloy CH9 is an ordinary Muntz Metal and easily meets the requirements for "G" Metal.

TABLE III.—*Chill Castings of "B" Quality.*

No.	Composition. Cu. per cent.	Zn. per cent.	Mn. per cent.	Fe. per cent.	Al. per cent.	Pb. per cent.	Casting Qualities. Behaviour in Pouring.	Surface Condition of Casting.	Mechanical Properties. Government Specification satisfied.	Yield Pt. tons per sq. inch	Max. Breaking Stress tons per sq. inch	Elong. per cent. $L = \frac{}{4\sqrt{\text{area}}}$	Appearance of Surface of Stressed Portion.	Appearance of Fracture.
J 2A	61.99	33.5	3.0	1.4	—	0.1	Pasty	Scabby	G Yield 8 tons sq. in. Break 20 tons ,, Elong. 20 per cent.	11.41	25.0	50.0	Smooth	Pale yellow; silky (resembling drawn rod) Cupped
J 2B	61.97	32.6	3.0	1.4	—	1.0	Ditto	Ditto	G Ditto	10.45	24.1	45	Ditto	Ditto
J 2C	61.81	29.97	4.79	2.11	0.21	1.1	Fluid	Very smooth and glossy	B Yield 12 tons sq. in. Break 20 tons ,, Elong. 30 per cent.	12.4	24.8	42	Ditto	Ditto
CH 9A	62.6	36.3	—	trace	—	1.0	Ditto	Fairly smooth	C Yield 6 tons sq. in. Break 20 tons ,, Elong. 10 per cent.	7.59	22.6	29	Very wavy	Full yellow: Dull

Of the alloys in the above table, one (J2 C) satisfies the requirements of the Government specification for B metal. It behaved satisfactorily in casting and machining. The copper was purposely kept at approximately 62 per cent. for the following reasons:—(1) Brass-casters often arrive at a higher copper content than required, *e.g.*, a mixture required to be 60-40 would often analyse 62-38 or even higher in copper. (2) It seemed advisable, when aiming to produce an alloy having a minimum of 30 per cent. elongation, to avoid those having an undue proportion of the beta constituent. The alloy CH 9A is given for comparison, being an ordinary brass, similar in copper and lead contents, but free from Al, Mn, and Fe.

TABLE IV.—*Chill Castings.*

Composition. Cu.	Zn.	Mn.	Sn.	Al.	Pb.	P.	Casting Qualities. Behaviour in Pouring.	Surface Condition of Casting.	Mechanical Properties. Gov. Specification Satisfied.	Yield Pt. tons sq. in.	Maxim. Stress tons per sq. in.	Elong. % $L = \frac{}{4\sqrt{\text{area}}}$	Appearance of Surface of stressed portion.	Appearance of Fracture.
88.0	2.0	—	10.0	—	—	trace	Fluid	Smooth	C Yield 6 tons sq. in. Break 12 ,, ,, Elongn. 10 %	11.1	18.36	10.5	Slightly wavy	Dull; granular
90.0	—	5.0	5.0	—	—	0.15	Pasty	Rough and scabby	C ,, ,,	11.5	15.5	11.0	Very wavy	Ditto
85.35*	10.09	—	4.48	—	.08	—	Fluid.	Very smooth	G Yield 8 tons sq. in. Break 20 ,, ,, Elongn. 20 ,, ,,	9.6	21.2	39.0	Wavy	Ditto

* This alloy was sent up to the Royal Arsenal, Woolwich, in the form of a nose-bush cast in a chill-mould (using a sand-core). The figures given were obtained in the Royal Laboratory.

TABLE V.—*Tests made at the Royal Arsenal, Woolwich. Chill Castings (Alloys for Fuses).*

Mark.	Composition by Analysis. Cu.	Pb.	Fe.	Al.	Mn.	Sn.	Zn.	Tensile Tests. Yield Pt. tons per sq. in.	Breaking Stress tons per sq. in.	Elongation. % $L = \frac{}{4\sqrt{\text{area}}}$	Remarks.
1	59.7	1.38	0.13	0.3	1.4	nil	diff.	8.5	28.5	28.0	Iron and Manganese introduced with the Copper as Ferro-Manganese; Aluminium, Lead and Commercial Spelter finally.
5	59.1	0.96	0.04	0.35	nil	nil	diff.	9.0	27.0	38.0	Commercial Spelter, Aluminium and Lead added last.
6	60.6	0.94	*2.0	nil	nil	nil	diff.	9.0	25.0	41.0	Iron bar in small pieces melted with the copper; Spelter and Lead added last.
15	59.2	2.12	nil	nil	*2.0	nil	diff.	9.0	24.5	36.0	Copper and Cupro-Manganese melted together; Lead and Spelter added last.
18	60.93	0.89	0.08	1.01	2.13	nil	diff.	12.0	30.5	32.5	
20	66.12	0.9	0.03	3.46	nil	nil	diff.	12.0	31.5	35.0	

All these alloys "machine" and "screw" well. *The compositions of Bars 6 and 15 have not been fully verified. The figures marked with an asterisk give the percentage aimed at; the others are actual composition. Lead has been intentionally added in order to represent as far as possible the worst conditions which could be obtained by using commercial spelter high in lead.

Development of Worm Threads and Worm-Wheel Teeth in Plaster of Paris.

By J. R. Moorhouse.

Engineers have a prejudice against cast worm gears, on account of irregularities in pattern construction and moulding. It is preferred to cast metal blanks, from which are cut the teeth so that a smooth and efficient working gear is obtained. There is, however, a condition in cast gears unlike those cut in forged metals that should have consideration, as this is possibly responsible for the short life of many of the most perfectly-designed gears.

One condition essential to durability for the worm and worm wheel is that the ratio of their speeds as dependent on their teeth profiles be exactly the same at every instant. This is only fulfilled so long as one tooth is the envelope of the relative position of the other. These conditions are now known as vital to the efficiency of worm gears, and it will be more readily understood why the wearing metal faces of the worm thread and the worm-wheel teeth should be uniform in grain and hardness.

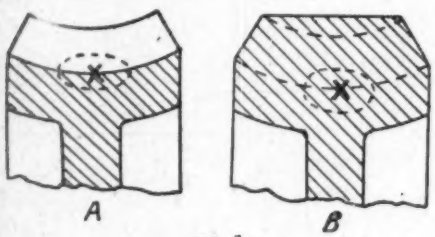


FIG. 1.

Cast metals, unlike forged metals, are not homogeneous; the quick cooling of the outer surface and slower loss of heat in the interior of a casting leaves the surface dense and close and the interior porous and open.

Reference to Figs. 1 and 2 illustrates how this natural law of cast metals is prejudicial to the life of worm threads and worm-wheel teeth cut from cast solid metal blanks. B is the section of the blank as cast, and A the section of the rim when cut through a tooth space, showing the amount of metal it is necessary to remove to finish down to the root of the tooth. This section is approximately 2½ in. deep and 4½ in. wide, with cuts 1¾ in. deep into the heart and most porous part of the section. Unfortunately, it is here at the point marked X that the angular velocity of the worm thread is greatest, and where the friction between the metal faces tends to wear more than at any other point during contact of the worm-wheel teeth.

This reasoning will also apply to the worm cast blank shown in Fig. 2. In these examples the pitch is only 2 in., and for coarse threads the relatively hard and soft points on the working faces of the teeth will be more exaggerated. That must sooner or later very seriously affect the efficiency of the gear.

The foregoing remarks indicate that by first relieving the spaces between the teeth to allow for machining a uniform wearing face is obtained on the teeth profile, and materially assists in maintaining the original tooth shapes and thereby the efficiency of the gear.

With the exception of wheels with really large pitches, it is argued that the cutting of wheels with relieved teeth destroys the cutters quickly, due to the hard skin and scale on the casting, and that the extra cost of the pattern with teeth for odd sets of gears makes it prohibitive. Against these objections, apart from reduction gears of extreme importance, the possibilities of casting accurate worm

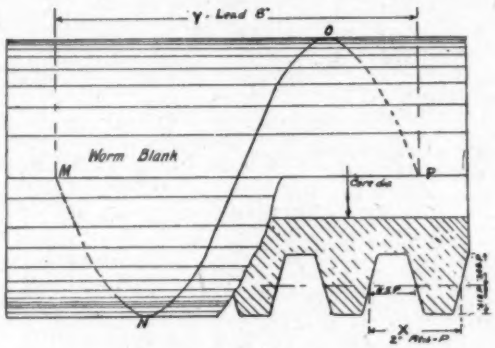


FIG. 2.

gears, to make the machining of both the worm and wheel unnecessary, have not been thoroughly tested.

With the aid of the modern wheel-moulding machine a mathematical division of the circle is guaranteed, and providing the worm-wheel tooth block has been accurately hobbed with the worm and set true in relation to the moulding machine spindle, a casting should be made to the merest fraction of an inch to the machined sample, with this difference, that other conditions being equal a far longer life is assured.

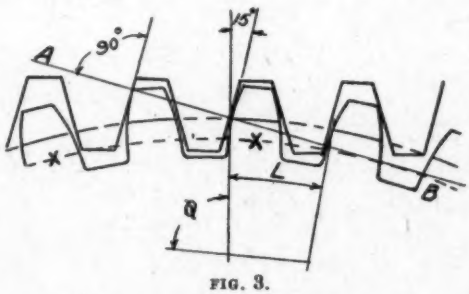


FIG. 3.

In cases where it is necessary to cut the teeth and it is preferred to relieve the spaces in the casting, in the manner previously suggested, it will be found that by pickling the castings all scale is removed and the skin appreciably softened, so that no excessive wear should show on the cutters.

The question of pattern costs should receive consideration in view of the entire costs. If a pattern worm is required to produce accurate castings in quantities, it is advisable to cast a bronze worm from a plaster-of-Paris master pattern, and finish

by chasing in the screw-cutting lathe. These castings should be made on end, the pattern being screwed out of the mould through a stripping plate. From a pattern of this description it is possible to cast a worm to the nearest $\frac{1}{32}$ in.

It is admitted that the cost of making such a pattern is prohibitive for ordinary requirements, and it is here intended to show how it is possible to construct accurate worm threads and worm-wheel teeth in plaster-of-Paris, from which fairly accurate

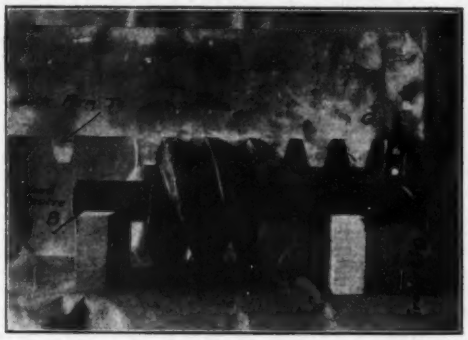


FIG. 4.

castings may be obtained. Such patterns will cost a mere fraction of those made in wood in the orthodox manner.

To obtain theoretically correct tooth profiles, so that a constant velocity ratio is maintained, there are two recognised systems used, and known respectively as the cycloidal and involute systems.

A worm or worm wheel with teeth having two curves, one to form the face and the other the flank of the tooth, are known as cycloidal teeth. Those having but one curve forming both the face and flank are most in favour, and are known as involute teeth.

Particulars usually supplied to the pattern shop for cut gears do not give the proportions of the teeth or their shape, as these are determined by the cutters used, which are standardised and numbered from 1 to 8 for involutes, and A to X for

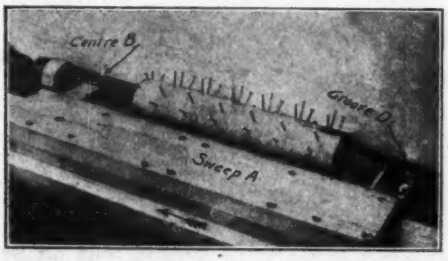


FIG. 5.

cycloidals. But if the teeth of a casting are to be relieved, it is necessary to know what proportions are to be finally used, so that due allowance may be made for machining.

The following proportions are given as representing good practice; the pitch is taken as the unit of proportion, and the worm gear laid out as Fig. 3, on a plane passing through the worm axis and normal to the wheel axis. The worm thread is as the teeth of a rack perpendicular to the path of contact, A B, with an angle of obliquity of 15 deg. The face or addendum of the tooth is 0.318 of the pitch, and the flank or dedendum 0.368 of the pitch; the thickness of the teeth is half the pitch, but for cast gears it should not be more than 0.48 of the pitch.

On these proportions allowance is made for machining. To describe the involute curve, draw a circle touching the line A B, making it a tangent. On this base circle lay a segment of a circle of the same diameter. With a piece of fine cord and a sharp-pointed hard pencil looped at one end, draw an involute curve by unwinding the cord around the segment. It will then be found possible to find a radius to describe any number of teeth that may be necessary to complete the lay-out.

The principle of sweeping the worm pattern in plaster-of-Paris will be readily followed from the views Figs. 4, 5, and 6. Referring to Fig. 4, a wood centre, B, is turned in halves to a diameter that will leave about one $\frac{1}{4}$ in. of plaster-of-Paris below the roots of the worm thread, and long enough to serve as a guide for the end stops on the sweep A, which fixes the overall size of the worm diameter.

The sweep A has cut in it a series of projections representing the spaces between the worm threads. These are accurately pitched and shaped as the lay-out, Fig. 3. For reason of strength it is advisable to have the grain of the timber running with the projections, and to stiffen the sweep with a broad batten screwed on the back. It will also be

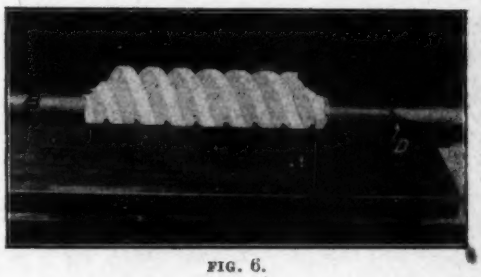


FIG. 6.

necessary to shape the sweep in the same manner as used for loam sweeps, as the plaster-of-Paris is applied in a similar way.

To give the necessary travel to the sweep A for forming the worm thread, a D-shaped groove $\frac{1}{4}$ in. deep and $\frac{1}{4}$ in. wide is cut into the wood centre B, so that on rotating the centre, and by means of the hard wood projection G engaging in the groove, the correct lead can be given for forming the worm thread. The groove cut in the wood centre may be accurately set out in the following manner:—

Take a piece of thin drawing paper long enough to just meet round the centre piece B; see that the edge is quite square, and cut to a width equal to the length of two leads of the worm. With the edge forming the circumference as a base line, measure up on the right-hand side a distance equal to the lead of the worm, for a right-hand worm, and *vice versa* for a left-hand. Assuming a right-hand worm, now draw a line from the extreme bottom left-hand corner to the point marked on the right-hand side of the drawing paper. It follows that if this be placed round the wood centre B a line is shown that will trace out a true helix.

A reference to Fig. 2 will show more clearly the relation between the pitch and lead which is necessary to be understood before completing the lavout for forming the groove. The pitch in multiple-threaded worms is the distance X from one tooth to the other, and the lead of the screw is the distance

Y which the worm will travel in one complete turn, represented by the helix M, N, O, P. For a single screw the lead is equal to the pitch, for a double-threaded screw it is twice the pitch, and in the example shown in Fig. 2, of a 2-in. pitch four-threaded worm, the lead is 8 in., or equal to four times the pitch.

If lines be drawn ½ in. away and parallel to this, it will show, when placed round the centre B, a ½-in. parallel spiral that can readily be traced and cut to leave the required shape of groove to give the correct lead of the sweep when forming the worm pattern. The centre B is now placed back in the lathe, and means provided to support the sweep A, so that a perfectly free movement is allowed to it. Another alternative is to fix the centre B on V blocks, as shown in Fig. 4. But if the lathe is used as shown in Figs. 5 and 6, more accurate results are got.

Means for securing the plaster-of-Paris on the centre B is provided by the use of flat-headed nails, as shown in Fig. 5. These are placed ½ in. apart, and stand out to within ¼ in. of the tip of the worm. They are readily located by tracing a line on the centre from the sweep.

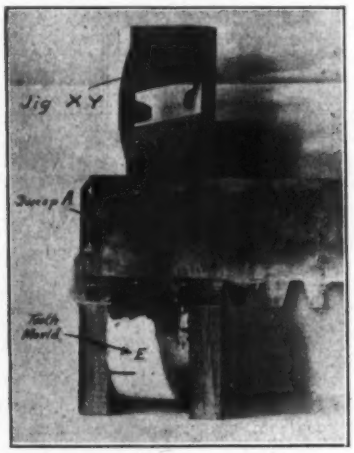


FIG. 7.

Everything now being ready for the placing of the plaster-of-Paris, the sweep and the groove in the centre are well oiled, the plaster is mixed thoroughly, and, while the centre is rotated slowly, it is dropped in a setting state, the flat-headed nails preventing it from running off the centre and securing it in position. The sweep is now brought quickly to position, and the hardwood projection G pressed well in the groove and held there during a complete turn of the centre. This will give the lateral movement of the sweep necessary to give the correct lead of the worm and remove the surplus plaster.

Having fixed the foundation, it is only required to repeat the operation with a thin mixture of plaster-of-Paris to finish the worm pattern in the manner shown in Fig. 6. The ends are now dressed in the lathe, and the prints turned down to size. A fine fret saw is used to part the worm along the joint, so dividing the pattern for moulding in halves.

When it is necessary to make a worm-wheel tooth block or pattern the centre B, Fig. 4, should be extended in length so that a block of plaster-of-Paris may be swept on it, in which is formed a groove to the required section of tooth. This tooth shape is obtained from the layout Fig. 3 and cut in the worm sweep A in the manner shown in Fig. 4 at T. It follows that the groove guiding the sweep must give the same lead to the tooth groove in the block E as is given to the worm. This block is cut from the centre B in Fig. 4, but shown in Fig. 7 between wood supports with the sweep A in position to illustrate clearly the principle of forming a tooth mould, in which may be cast any number of worm teeth, with the assurance that they will accurately agree with the layout in Fig. 3. The tooth block E must be a trifle larger in diameter than the worm to give the required clearance at the roots; this is readily found by measuring the distance on the layout from the worm tip to the worm-wheel tooth root and cutting back the sweep to suit.

The method and process of sweeping this tooth groove are the same as described for the worm, and may be done at the same time. In cases where no worm pattern is required, it will be seen that both time and labour can be saved by shortening the worm sweep and the centre, also cutting the spiral groove just sufficient to give the required travel for forming the tooth mould. It is, however, advisable where accurate worm wheels are required always to make a worm, so that the worm wheel

FIG. 8.

tooth may be hobbed into it; but in these cases where the worm wheels are to be finally cut, and it is only required to relieve the teeth to give a uniform wearing metal, it is unnecessary.

It is generally supposed that worm-wheel teeth are parallel sections conforming with the lead of the worm; but an examination of a worn worm wheel will show this to be otherwise; in Fig. 10 C is a plaster tooth cast in the tooth groove block E, and similar to a worm wheel with teeth cut by a circular cutter, but not hobbed. The tooth A is a plaster tooth cast in the same tooth block, but hobbed into the worm, so that at all positions during contact line contact is maintained. The difference is noted by the shape of the tooth outline, and shows the outer ends cut away to remove any interference.

To lay out the various sections of a worm wheel tooth is an intricate geometrical proposition that would be difficult to follow in practice. But with the method here suggested any number of teeth may be accurately and simply made.

Referring to Figs. 7, 8 and 9, a jig X, Y, is made the shape of the tooth, and rests in the tooth groove of the block E. It is of vital importance that this jig be carefully made, as otherwise the teeth will

not be correctly spaced. All particulars are obtained from Figs. 1 and 3. The pitch L and angle ϕ will be determined by the amount of plaster allowed on the back for fixing to the pattern or pattern block. For medium pitches $\frac{1}{2}$ in. of plaster will be found sufficient. Fig. 7 shows the jig complete on the sweep. Fig. 8 shows the jig in position on the tooth block, the plaster-of-Paris run in, and the back being strickled off. Fig. 9 shows the jig removed, with the tooth still remaining on the block.

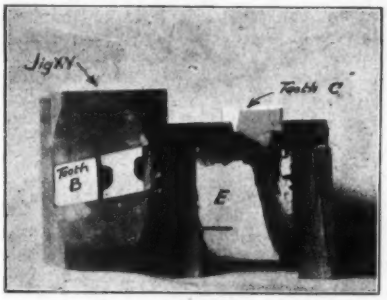


FIG. 9.

Fig. 10 shows the teeth, first as removed from the block at C, and hobbed at A. Those teeth shown at B are required for making a full pattern in halves; one of these is shown in position in the jig at Fig. 9. These are made by first cutting a tooth to correct length and placing back in the jig, and then running the number of required halves up to it on the tooth block E.

For making a tooth block, or where it is preferred to mould the teeth in a core box, first cast three teeth, then clamp together and hob in the usual way. Now place back on the block E the jig X, Y, cut away the plaster on the inside, and bore a 1-in. diameter hole right through the block. Place the hobbed tooth back in the jig and invert the block and fill up with plaster through the hole provided. It is evident if the tooth has been accurately hobbed that any number of teeth can now be run in the groove block E that will not require hobbing, and be an exact duplicate of the master tooth.

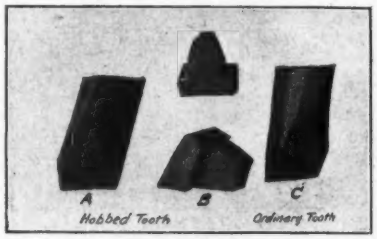


FIG. 10.

A cast worm wheel made from a pattern so constructed must be in regard to the tooth shape quite accurate, and if made on the wheel moulding machine the divisions and pitch cannot vary.

For repetition work a bronze worm-wheel tooth block made from a plaster-of-Paris master pattern as described and worked on the wheel moulding machine should produce castings at a fraction of the cost of machined and hobbed blanks.

It has not been thought necessary to show the general construction of the worm-wheel pattern proper, as these are made in the usual way. The plaster-of-Paris teeth are secured by a shellac varnish. They are first given two coats and allowed to dry thoroughly; also the wood pattern on which they are to be secured is varnished. They are then varnished on the backs and placed in position, and time given for them to set before using.

Cost of Production in the Open-Hearth Process.*

A comparison of the results obtained at Witkowitz, Hoesch, and other works shows that the hot-metal process undoubtedly gives a considerable saving in respect of fuel consumption per ton of steel, life of the furnaces, reduced consumption of ferro-manganese, recovery of marketable phosphoric slag, and quicker working of the charge. None of the various processes examined, however, is considered to afford the best solution of the problem of steel-making, all being insufficiently adaptable to sudden market changes, since the use of a high proportion of scrap retards the working of the charge to an excessive degree.

Although it is really impracticable to establish a comparison between the relative costs of production by the hot-metal and scrap processes, the author has attempted to do this from the data furnished by a month's working at a 7,000-ton steel works. The materials of the charge cost 66.42s. per ton of steel, fuel 4.53s., additions (ore, limestone, aluminium) 0.68s., furnace lining 2.76s., ingot moulds 0.81s., labour 3.31s., repairs 0.70s., electric power; pumping, etc., 0.98s., stores 0.27s., spare parts, etc., 0.82s., sundries and depreciation 1.20s., total 82.48s., less 1.15s. for slag, etc., and 1.44s. for casting scrap, etc., or net, 79.89s. per ton of steel. Since of this 64.97s. represents cost of charging material, the conversion costs 14.92s. per ton of sound ingots. In a second steel works (scrap process) the cost of fuel was only 3.19s., as compared with 3.78s. at the Dortmund Union works and 3.60s. at Witkowitz.

With regard to the relative cost of furnace linings for the scrap and ore processes respectively, this is given at 2.10s. to 2.76s. for the former (the lower figure being for a 45-ton furnace running 480-550 charges between renewals), and 1.40s. to 1.46s. for the ore process (a 200-ton Talbot furnace running 800-900 charges, and a 60-ton Wellman tilting furnace running up to 1,500 charges); but the comparison is regarded as of doubtful value. The author's conclusion is that working the two processes is the most economical plan, since it enables market fluctuations to be fully taken advantage of.

PLUMBAGO FOR MOULD FACING.—According to H. F. Frohman, in "The Brass World," Ceylon graphite (high grade for facing purposes) should analyse about as follows:—Moisture, 1.20; oxide of iron, 5.90; aluminium, 3.06; lime, 0.90; silica, 16.14; graphite carbon, 72.80. The bulk of Ceylon graphite used for foundry facings runs between 50 per cent. and 60 per cent. graphitic carbon. These are straight Ceylon graphites, untouched by the manufacturer. Coke blacking, which is used on certain classes of work, should analyse:—Fixed carbon, 88.0; ash, 9.0; sulphur, 0.8. Anthracite blacking when used as a pipe blacking or mineral facing should show:—Moisture, 7.0; fixed carbon, 84.0; ash, 9.0; sulphur, 0.5. A good grade of charcoal facing which is generally used by the foundries, not only for parting purposes but also for foundry facing, and as a core wash, should analyse:—Volatile matter, 10.0; fixed carbon, 85.8; ash, 3.7; the ash varying according to the kind of wood and time of cutting.

* W. S. Schomburg, in "Feuerungstechnik."

Foundry Risks and Remedies.*

By A. R. Bartlett.

The more care we take, the more caution we exercise, and the more thought we give to others' safety—the fewer risks there will be run in the foundry. The majority of foundry accidents are caused by the want of care on the part of someone; either the workman or possibly the foreman, or even the manager does not care enough. Neglect to obey orders; the stupid play of some man or boy, such as throwing loam or sand, often causing pain and possible blindness; improper handling of liquid metal, either in bad ladles or ladles not properly dried; wearing bad boots or low ankle shoes; wearing turned-up trousers which catch the splashes of metal and often cause burns on leg or ankle; falling of a pig-iron stack that has not been piled correctly, thereby causing injury to hand or foot; the nail protruding from a pattern, or the foundry sprig run into the hand and the wound not being cleaned and dressed properly, causing blood-poisoning and often serious results; water poured carelessly into the overflow from a riser, causing a blow-up; unevenness of the foundry floor and obstructions in the gangway—these are some of the causes of the risks we run every day. Therefore, the greatest enemy to safety is carelessness.

Danger and caution are not looked upon by the majority of workmen with the seriousness that is really essential in the foundry. He will get into the way of taking chances, until his foolhardiness involves him in some injury or someone else suffers for his want of care. The foreman or manager should insist on his workers taking no chances. In this manner the whole of the blame for preventable accidents falls back on the men in charge. It must be admitted this is rather hard on the foreman who has not got a very orderly or well-behaved staff of workers, but it appears the only way possible to prevent accidents from carelessness. Example, we know, is better than precept, so all foremen should see that the gangway is clear. They should not step over the obstruction and take no notice; and they should set the example of wearing sensible boots and clothing for the work of a foundry. Often the employer provides safeguards for the use of his workmen, such as goggles, spats or leggings, gloves, and respirators, but there is always to be found the man who is foolhardy enough to resent their introduction, and who will not use them until he has the lesson brought home to him by suffering pain which he would have avoided by their use. The indifference to danger is the greatest danger.

Storage of Boxes.

Foundry yards are not always used for storage as they should be. The boxes are stacked in a very careless manner; often can be seen the small box at the bottom of a stack, and then the inevitable happens when some moulder is looking for a box part; he starts climbing up the stack to seek his box, when down comes the top boxes: result—broken box parts and very possibly injury to the man. This, of course, could be avoided by proper supervision from the foreman, who should insist on all boxes being stacked according to size. If not possible to stack each size by itself, the largest should be at the bottom and the smallest at the top. In fact, everything should be done that will make foundry operations fool-proof. Order always makes for safety, so the pig-iron should be stacked so that no chance of the pile falling is possible, as this is one of the most frequent causes of nasty accidents.

An important feature in the storage of boxes is the ease with which the desired box can be found. We have a method of numbering every size of box, and each box has its properly arranged place in the yard, with posts, having the numbers painted on them, fixed in the ground. In the office is kept a list of the boxes, stating their number, the internal measurements, the depth under stays, and the depth over all. Knowing this, it is not necessary to waste time in seeking the right-sized box; also there is no need to go out in the rain or inclement weather. The only thing necessary is to tell the yardman to send in the box required, giving him the number. Then, when done with, it is returned to its place again.

Naturally, an orderly yard is always accessible and more commodious than a disorderly one. The disorderly one causes the men carrying hand-boxes to stumble, and some hurt, even if only slight, is sure to happen. If the lanes between boxes are kept clear, light gets between them, and thus accidents are avoided. Also if the gangways leading from the foundry are kept clear, it greatly facilitates the getting of all materials into the shop and the removing of all rubbish from the shop. This helps to preserve safe and orderly working in the shop and adds to its productive capacity. One should always try to keep permanent pathways, so that no one has to clamber over heaps of rubbish or scale the heap of scrap or pig-iron. The straighter the path the less likelihood the man pushing the barrow has of hitting his knuckles or being overbalanced, and the quicker and easier he will do his work. Remember that foundry sand makes mud in wet weather, and water in the boots does not help to keep men fit, while ashes will make a dry path. If the scrap is stored in a pit it should be guarded by a rail, so that no one can fall in, as scrap has a tendency to hurt if met awkwardly. Be sure that any manhole in the yard is secure and will not tip when trodden on the edge. See that there is sufficient room between railroads and all stacks of material for a man to pass safely. The safe foundry yard will thus be orderly and the most efficient.

The Foundry Floor.

The foundry floor is where most risks are run. Here is got the spilt metal, which is the cause of most accidents in the foundry. Always soften the sand on the ground under the runner box of the job to be poured. This will stop the splashing from any metal that fails to enter the runner box, the soft sand allowing the metal to sink into it and be retained, where if it falls on hard ground it would fly about.

Other causes are obstruction in the gangway resulting in the man carrying the ladle stumbling and burning himself and his shopmates, the narrow path winding in and out of irregular-placed boxes resulting in knocking the ladle against the boxes

* Paper read before the London Branch of the British Foundrymen's Association, January 14, 1916, Mr. A. Willis in the Chair.

and spilling the metal, while climbing over boxes and heaps of sand has the same result. These same heaps of sand and badly arranged boxes are often the cause of accidents, when the men, in their haste to get away from the flying metal, fall over them and not only get cut and bruised, but get much worse burns than they would have got. Of course, a clean path is easier obtained in a shop where work is standardised than in a jobbing foundry, but it always helps to keep men from harm.

It is well to keep the floor clear of everything that will hang up; this not only prevents possible accidents, but helps to get work done quickly, for the tools can be found when wanted. We have found it to our advantage to have some of the floor staked off, so that only a small class of work can be done there, thus keeping the paths always clear where metal-carrying by hand is done.

Neglect to see that there is sufficient room for the ladle and the men manipulating it, when the metal is being poured into the mould, is liable to cause spilling. Do not allow clamps, skimmers, wedges, rammers, rods, or any tackle to be thrown from the top or side of the box just cast while metal is being carried, but see that this is done after pouring has ceased. Try to have a place for everything and see that everything is in its place. Do not pour spare metal where it is likely to be trod in, and do not allow it to be covered with sand while in a liquid state. This is often the cause of a very badly burnt foot. Always remember that the foundry floor is for moulding. Remove patterns to a proper storage place, as they are a stumbling-block if left where the moulder drops them when he has drawn them from the mould. They will also get spoilt if hot metal touches them. Do not keep barrows or other large tools in the foundry when not in use. They will be sure to be in the way if there is a burst-out or a core wants carrying up the shop.

Ventilation and Lighting.

The foundry is a very dusty place; avoid this as much as possible by keeping the floor damp enough to stop the sand rising in the shape of dust. According to statistics, the foundry has the second most dusty and impure atmosphere in the manufacturing world, and from the death returns of moulders the greatest number die of chest complaints, greatly due to the dusty nature of their work. The better condition the shop is kept in the more likely is it that a good class of workmen will be got, for the best men appreciate good working conditions.

Keep all windows clean; the better the natural light the less likely are accidents to happen, and the cost of artificial light is kept down. To assist the lighting arrangements, keep all walls whitewashed; this also tends to sweeten the air and improve health. See that the light is not obstructed by badly-arranged machines or stacks of boxes.

We must have artificial light for dark days, but see that it so placed that no dark shadows are thrown from it, and that it is of good quality and sufficient quantity to make the foundry a workshop and not a place in which men grope about and stumble. Good lighting will pay for itself, for accidents will be avoided, more work will be done, eyes will not be strained and injured, and thus the work produced will be more efficient.

A well-ventilated foundry tends to prevent accidents, for the reason that the health of the workmen is kept good, and a healthy man can take interest in himself, his shopmates, and his work and surroundings. The properly ventilated shop allows the fumes from molten metals to get away, and especially is this the case in the non-ferrous foundry, where the fumes from zinc may injuriously affect the health of the men.

Much objectionable smoke arises from core ovens, also from moulds, especially those containing large cores, or cores where straw or hay is used. Some binding compounds give off very objectionable fumes. The pickling tank and the sand blast, the open fire and other methods of drying, all have their unpleasant features.

Some of the risks have been lessened by the use of respirators where men are continually on one class of work, such as the sand blast. But for the majority of foundry workers the ventilation of the shop is the only safeguard, and natural ventilation, as a general rule, is the only one in use. A good installation of forced draught would remove most of the fumes and dust arising in the average foundry. In the sand-blast process it is usual to employ some form of forced draught, but even here I have found a want of care on the part of the operator, for though helmets, gloves and respirators are provided, it is no unusual thing to find him doing without one or the other and thus running risks.

Badly arranged ventilation causes great unpleasantness by draughts, and as most foundries have no proper heating arrangements, an open coke fire is lit, and placed so that it warms the cold draught, but in doing this an added discomfort is put in the shop by reason of more fumes from the coke. It is now usual in an up-to-date brass foundry to have ventilating hoods over the furnaces, thus assisting in clearing the shop and conserving the health of the workers. If oil or other binders which give off a large amount of smoke are thoroughly mixed with the sand, the resultant smoke is not so great as in an inefficiently mixed compound. Also if the oil is thoroughly mixed a smaller quantity is needed, and so an economy effected and less smoke given off. The crane driver is the man who has to put up with the greatest inconvenience in this matter, so see that all fires that are lit with wood are allowed to get well alight before coke is added to them. This especially applies to the open fires that are often lit in ladles. The rumbler or tumbling barrel is a fruitful cause of dust, and should be placed in some part of the shop where the smallest number of men are working, or, if possible, in a room with a forced draught.

Cranes.

The crane in the foundry is one of our chief tools, a servant on whom we depend for a great deal of help. See that it is safely equipped and carefully operated, and then it will be a most reliable tool. If the load should fall it is ruined, that is if it is a mould or core, and if it should happen to fall on other work that also is spoilt, and if it fall on any of the workmen, injury is the result. If molten metal is dropped from the crane there is the added danger of burns. As a general rule all risks from loads falling from cranes can be avoided by careful driving and slinging, and a keen inspection of the crane. The hoisting chains or wire ropes must be looked to, and all gearing should be periodically examined. The brakes should be in perfect order, for ofttimes a load will come down with a run if the brake does not hold. Of course, proper lubrication of all moving parts is absolutely essential, not forgetting that the wire rope or hoisting chain wants lubricating. Remem-

ber the dust that accumulates on the crane drops equally in the grooves of the hoisting drum and other working parts, so should be removed; also if a surplus supply of oil is given, it helps to hold the dirt where it is not wanted, thus helping to get the crane out of order. The oil that overflows from bearings on to the platform of the crane, where dirt is allowed to accumulate, makes slippery places for the crane man or millwright if he is employed in inspecting or repairing the crane, and the possibility of a slip with unpleasant consequences. An excessive use of oil is not only a waste, but it is a nuisance to the man working under the crane, and if he should happen to look up at the same time as the oil is falling he runs the risk of pain and injury to his eyes.

Avoid sudden stops and starts, for this puts undue strain on every part of the crane; also it has a tendency to strain the lifting chains if hoisting or lowering, and is a fruitful cause of them breaking, when the usual loss and risks result. If the chain links appear faulty have them renewed; it is far cheaper and safer, for loss and injury are avoided. Treat wire ropes the same, if the outside strands have worn through and are protruding; for when once started the fracture increases very rapidly, and we cannot afford to use faulty hoisting ropes where hot metal is concerned. Dirt helps to wear out the teeth in the geared wheels, so keep a keen eye on them, for teeth if they start to strip fly off very quickly, and the impetus thus given to them, if stopped by some worker's head or body, causes injury and pain.

Some cranes have gear cases, and then, of course, the dirt does not do so much harm as would otherwise be the case. Electrically driven cranes always have their motors covered in this manner, but I find from experience that these should be regularly examined, for if neglected a stoppage takes place and may possibly cause great delay and unnecessary worry and trouble. See also that the wiring on the electric crane does not get the insulation worn off and neglected, and that there are no exposed parts for the men to get a shock from; for if it is severe and the man falls he is liable to receive very serious injury. Provide a safe means to get from the floor to the crane; have the ladders fixed at the ends of the shop so that they cannot be removed. The driver can then place his crane at the end of the shop out of the way. I witnessed a very bad accident through the ladder being placed in the middle of the shop. The driver of one crane was coming down and another crane was travelling up the shop at the same time. No one noticed the man coming down, with the result that the crane passed over one of his hands, permanently injuring him for life. If the ladder had been at the end of the shop it could not have happened. Have a guard-rail round the footwalk of the crane, also a board on edge to prevent any tools from shaking off. Better still, provide the crane man with a tool-box and see that he uses it; give him enough oil and waste for his requirements and time enough for proper cleaning. Do not lift more than the crane is designed for, as then is the time when the weak part gives and the risk is run. Have the lifting capacity of the crane plainly marked, so that everyone knows what is a safe load. By this I mean that the figures should be large enough to be seen easily from the ground and naturally in a conspicuous position.

Chains and Slings.

From cranes we naturally follow on to chains and slings. Here caution will ensure safety. All chains should be carefully annealed at regular periods. Do not assume that making them hot and allowing them to cool is going to add to their strength; it does not, but it will restore the fibre of the iron if the material they are made from was originally good. Of course, the period of annealing will vary according to size of chain and the amount of work it has to do. We always anneal ½-in. chains and under every six months, and all chains above ½ in. every twelve months. That is, if they have been in constant use.

It is generally contended that chains that are used in foundries should be annealed more often than those in works where they are not subject to lifting hot loads. It is advised by some authorities that all such chains should be annealed every three months.

The lifting power of a chain greatly depends on how it is placed on the job to be lifted and at what angle it is situated from the crane hook. Thus if a chain is lifting perpendicularly under the hook it will take a much greater load than if it is used to take a bight round a job, and, again, it will lift more if it is doubled. If two or more chains are used and they are lifting at an angle of, say, 60 or 45 degrees, each individual chain will not lift as much as the chain that is perpendicular under the crane hook—that is, if of the same size. If the chain is allowed to catch on sharp edges of castings it will get cut and weakened, and the ragged edges so formed are liable to cause injury to the men handling the chain. A piece of wood or sacking will save this damage and remove the risk to the workmen, and at the same time will stop the risk of slipping. A list of safe loads for different sizes of chains should be hung in a conspicuous position, and all slingers should be supplied with such a list. All screw chains and hooks should be hung up, otherwise the screws will get spoilt by the sand and the hooks will not be found when wanted. If lifting a load with two or more chains, see that each chain has an equal proportion of the load. Use wood packing or pieces of wrought iron between the links to adjust the length if necessary. On no account should knots be tied in slings or chains. Have a diagram in the shop showing the relative strength of chains according to the angle of slinging.

Wire ropes or rope slings, no matter of what material they are made, are more reliable if spliced than if treated in any other manner; but be sure that the man who does the splicing is efficient and does his work properly. Do not run the risk of a casting dropping. See that it is slung by attaching the chain or sling to the body of the casting and not by a bight round the runner or riser. One never knows if there is a hidden flaw there, for that is usually the weakest part of the casting and only needs a blow from a hand hammer to break it off. Avoid putting a load on the points of the chain hooks; not only does it strain the hooks, but there is the liability of the hooks slipping and the load dropping. Have handles on the boxes, so that the hooks can be used. It is common practice in some shops to lift by a lug placed on the top edge of the box, as it costs more to make boxes with handles or trunnions.

Slingers and Crane Drivers.

The safest and most efficient hoisting accessory is a careful slinger and a crane-driver with ample common sense and sound judgment. Careless or inexperienced cranemen by one false move will cause a large amount of danger and unnecessary suffering; therefore, only employ a man in this capacity who is known to be careful and reliable. See that he is a man of good habits and steady

nerves, good-tempered, not hasty to take offence, physically fit—in fact, as far as possible a perfect man. The first man picked up will not always make the ideal craneman, but if you are forced to train a man who has no experience of driving, be sure he has all the above good points. Then start him with some reliable driver and on the smallest and most easily driven crane. If he cannot successfully manipulate the small crane it is no use putting him on a larger one. The slinger should be a man who can give orders in a distinct manner, as well as being a capable workman. He should also be endowed with a large amount of patience and common sense. Have a spare crane-driver and slinger, even if you have to pay them a small retaining fee. It will pay; for not only will the lives of the workmen be safeguarded, but the crane will not suffer from inefficient handling, and the work will not stop when the regular hands are ill or unable to come to work. Impress upon the craneman the need of thoroughly examining the crane when lubricating, for slight faults increase into large ones when neglected. Point out to him the danger of doing any operation before he has orders, no matter how well he knows his work, for the slinger can see better than he when the load is high enough and knows where he desires to place it. He should never try to use more than two motions at once, as he has only two hands and may have to stop at once to avoid danger.

The driver should watch the hoist drum very closely when lowering a load to the limit of his rope or chain, as he is the only one who can see properly how many turns are left on the drum; under no consideration should less than two turns be left when the load is at rest. He must also exercise the same care in not going too high and running the risk of breaking or jamming the rope-block. Impress upon the slinger to warn all workmen to keep clear of suspended loads, and see that he walks ahead whenever possible for this purpose. Do not allow him to ride on suspended loads, for chains will break sometimes, and he will get hurt if this happens when riding. When a mould or core has to be finished overhead, rest it if possible, so that the strain is removed from the chains.

Molten Metal.

When molten metal goes adrift it usually causes damage and injury, and certainly it must cause some loss, for it is melted with the intention of making castings. Therefore, see that the ladles are in good order. They should always be lined in a proper manner and thoroughly dry. Have all ladles properly balanced, otherwise they are liable to be upset when filled. All gears must be in good order, so that there is no dropping when pouring. Have gears cleaned and oiled every day before using, and have guards over all gearing, for the small shots that fly when the metal is running from the cupola are liable to drop into the gearing, and if not noticed the casting may be run short on account of the impossibility of turning the ladle any further. When a hole wears in the ladle have it repaired, or scrap it if too far gone; a run-out from the ladle is wasteful and dangerous. If the ladle is ungeared, see that it is fitted with an efficient stop, so that the bail will remain upright when the ladle is lowered on the ground or trolley, for the sudden dropping of the bail is liable to upset the ladle. Have the lips of the ladles shaped so that a perfect stream flows when pouring takes place; a broken stream ofttimes falls outside the runner-box and burns are frequently the result, and metal is wasted.

Hand ladles when not used correctly are a most fruitful cause of burns. Instil it into the user to cut into the stream of metal from the front when catching, and when carrying from the furnace see that the ladle is placed behind him, for then he can see where he is going and can warn others to get out of his way. He should always endeavour to carry the bowl level to avoid spilling.

Avoid having a tall man and a short man carrying a two-handled shank, for the short man is liable to receive the spilt metal, and also the workmen who are being passed are liable to be burnt from the same cause.

See that the bail of the crane ladle is vertical before lifting from the furnace, and provide the slinger with a properly shaped rod to guide the crane-hook into its place and long enough to keep him from feeling the excessive heat of the metal. Do not put an entirely new hand to carry metal; wait till he has got accustomed to seeing others do the work, and then put him with an old hand. If a lot of carrying is done make it a rule that all men should keep to the left when passing one another. Advise men when pouring to keep their feet as far away as possible from the mould poured, for at times there will be a run-out. Also train them to stand firmly when pouring, for a man who alters his position is liable to burn himself and others, and also cause the stream to stop, with the result that dirt enters the mould and a dirty casting is made.

Crucibles.

Crucibles are a delicate tool and need careful handling. Even when new they are not strong. The care of crucibles should be enforced as soon as they are received by the foundryman. Inspect them carefully for flaws, and if imperfect they are of no use for melting and carrying metal. Keep all crucibles dry. Place them in a stove for preference, or, if that is not available, put them at the back of the fires or in some other place with a dry atmosphere. Dampness causes steam when the crucible is put into the furnace, and cracks and burst pots are the result. See that the coke is dry before placing it round the pot when in the furnace. Gradually heat the crucible before using it for the first time. If it is heated rapidly the expansion is rapid and the steam in it causes a form of explosion and the pot is liable to break.

Crucibles become soft and pliable during melting of the metal, so see that undue pressure is not put on them when being lifted from the furnace, otherwise a weakness is formed at the indentation so made and the breaking-point is started. Keep the bottom of the crucible free from clinkers and have the fire level when placing the pot in. It is quite common practice in some shops to place a firebrick under the pot in the furnace to save distortion of the bottom. This distributes evenly the weight of the metal when melted in the pot.

Charge the metal evenly in the pot, otherwise it will get out of shape. All metal should be removed from the pots, so that they have every opportunity of cooling evenly. Lift the pot on the opposite side to the lip; if lifted with tongs by the lip the pouring may be spoilt and metal lost. Clear away clinkers or clinging coke from the sides of the pot before carrying away, as they are the cause of undue pinching and possible breakage. The proper care of crucibles reduces the risk of injury to workmen.

Machinery and Cleaning Apparatus.

In all foundries some form of machinery is installed; it may be an engine, dynamo, air-compressor, or some form of mechanical tool such as

sprue-cutters, emery-wheels or tumbling-barrels. They will have moving parts. These should be protected so that they do not get damaged by the careless workman and also to protect the workman himself. Guards should be placed wherever practical. Have notices placed in a conspicuous position warning men against removing guards while the machine is in motion. Do not allow belts to be put on by the amateur or when the machine is in full swing. Slow down always to put belts on. The abuse of emery-wheels is the most frequent cause of their breaking, and the flying pieces are highly dangerous. Keep all moving parts of every machine lubricated. Keep all obstruction away from all machinery, as a stumble induces men to put their hands out to save themselves, with the result that they are injured if coming in contact with moving parts.

Think of the risk run from flying chips from the trimming shop. Have it removed from where men are continually passing. A chip in the eye often causes the loss of eyesight. Have hammer shafts securely fitted to the heads. A flying head will reach some mark. Pinch-bars that have become worn at the base often slip, and bruised fingers are caused. Avoid all defective tools. Impress upon all workmen to call the foreman's attention to such. Provide protective clothes or appliances, and induce the workmen to use them.

I might go on to a much greater length and deal with the risks that are run and should be avoided in connection with the cupola, furnaces, and stoves—the want of proper sanitary arrangements, the need of good drinking water and some satisfactory arrangement for the storage of men's clothes and tools; for, to my mind, the contented workman is more likely to be a healthy workman, and your returns will justify your outlay and thoughtfulness.

There is a safe and an unsafe way of doing everything. It is the duty of us all to influence the workman into the safe way, point out to him the risks he runs to himself and others, until he realises the need of caution; and then see that he continues to practise the safe way. Practise ourselves the safe way, for by example and tact we may remove the risks and apply the remedies.

Discussion.

Mr. J. Oswald, referring to the protection of legs from splashed metal, remarked that the leggings suggested by the Board of Trade involved greater danger than unprotected trousers, by reason of retaining any metal that splashed over the tops.

Mr. Neil remarked that the leggings in use at his foundry were worn under and not over the trousers. As to the stacking of boxes, he had a row for each size, duly numbered, and this system had reduced accidents from about one per week to none since the change.

Mr. Bartlett referred to an accident incurred by a man through wearing low ankle shoes and no leggings. He agreed that the leggings should be worn under the trousers.

Mr. Stone asked whether Mr. Bartlett oiled the spats supplied in order to keep them soft.

Mr. Bartlett replied in the affirmative, stating that the material was very heavy leather, but was kept in condition by oiling every week.

Mr. W. Ellis suggested the use of expanded metal as a screen to stop flying chips from the cleaning floor.

Mr. H. G. Barrett referred to the dangers and discomfort of leaking roofs, stating that it was not uncommon to find a moulder in showery weather having to waste time in searching for cover-boards for his moulds as they were finished, in order to prevent damage from roof-leaks and droppings. For leather leggings soft soap was just as effective as oil.

Mr. W. Ellis, in respect to a suggestion as to heating foundries, said he had had hot air laid on, but found it dried the sand and the smell was objectionable.

Mr. Bartlett, however, said they had to light fires in the foundry in very cold weather to prevent the frost getting into the sand—particularly the loam.

Mr. A. Willis (the Chairman) said that there were various methods adopted to remove the fumes from brass foundries, but under the regulations no particular system was advised, and the inspectors appeared to accept almost any attempt to deal with the matter, it being left to the discretion of the manager. The difficulty of removing the fumes lay partly in the fact that they were discharged from the pot first on withdrawing from the fire, then at the skimming place, then at the moulds in pouring. As to respirators, he considered them unhealthy. The best precaution to take was that of breathing exclusively through the nostrils. He considered the dust was more harmful than the fumes in the foundry.

Further discussion took place on various points, and the meeting closed with a hearty vote of thanks to the author.

MACHINE-SHOP EQUIPMENT AND METHODS.—A survey of the development of machine-shop equipment, methods, and processes during the past twenty years formed the subject of two papers presented at the recent International Engineering Congress at San Francisco by Mr. E. R. Norris, director of the manufacturing operations of the Westinghouse Manufacturing Company and Mr. H. F. L. Orcutt, of Rowington, Warwickshire. Chief among the developments touched upon was the discovery of high-speed steel, and it was held that the other improvements came largely as a result of the heavier duty imposed on machines by it. The change in the composition of high-speed steel from the time of the invention of Mushet steel (the first of the high-speed steels) to the present was shown in the following table :—

	Mushet (Air Hardening).	Midvale (Date 1895).	Recent Make (with a Trace of Nickel and Copper).
Tungsten	5.441	7.723	16.28
Chromium	0.398	1.830	4.26
Carbon	2.150	1.143	0.63
Manganese	1.578	0.180	0.10
Silicon	1.044	0.246	0.141
Phosphorus	—	0.023	0.008
Sulphur	—	0.008	0.018
Molybdenum	—	—	0.55
Vanadium	—	—	0.26
Cobalt	—	—	3.47

The latest development in cutting material was shown to be that of stellite, which has the following composition: Cobalt, 52.03; chromium, 29.36; tungsten, 12.71; iron, 5.35; nickel, 0.45; manganese, 0.24; silicon, 0.009; molybdenum, trace. As stellite cannot be forged, rolled, or machined, is extremely brittle, and as tools made from it must be well supported close to their cutting edges, its uses are at present somewhat limited. Stellite tips may be brazed or electrically welded to shanks of carbon steel, and when so treated may be used until repeated grindings render the stellite very thin. Under favourable circumstances cutting speeds may be greatly increased by the substitution of stellite for high-speed steel. Cases are on record where cutting speeds on machinery steel have been quadrupled, and cutting speeds as high as 300 ft. per minute have been used in cast iron.

A New Bedding-in Method of Green-Sand Moulding.*

By M. E. Gallon.

In bedding in a pattern, the method generally adopted is to place the pattern on the floor and dig around it, leaving a space of from 4in. to 6in. right around the pattern. The depth of the hole is regulated according to the depth and the contour of the pattern, leaving a space at the bottom of the hole from 2in. to 4in. for loose sand on which to bed the pattern. There is no fixed rule for the making of this bed, consequently nearly every moulder makes it differently, with the consequent varying results. When the bed is made, the pattern is knocked down and levelled with the spirit level, or if it be a machine frame or a bed plate it is winded with the winding straight edges. The facing sand is then built around the pattern, some 4in. or 5in. high. This is backed up with black sand, then carefully pin-rammed, and if the pattern is 6in. or 8in. deep the moulder will probably flat-ram the first course. Then he carefully removes all black sand from the face of the pattern and again goes round with the facing-sand, this time building the facing-sand up to the top of the pattern. The black sand is again filled in to a little above the top of the pattern. This course is again rammed with the pin-rammer, then a little more black sand is added, trampled down with the feet and flat-rammed. The parting is then made, the top box is put on and facing-sand and lifters put in where required. On the top of this is riddled a little sand through the quarter riddle, finishing off with the ¼in. riddle. Then the rough sand is filled in to the height required, and the gate and flow-sticks and any wires or hooks are straightened and the box is rammed up with the pin-rammer and flat-rammed in the usual way. The guiding stakes are securely driven in and the top box is then lifted off and turned over. The parting is brushed off and the pattern drawn; the face of the mould vented down to the coke bed, if there is one, and if not the vents are connected from the sides. The mould is then finished and the top box replaced, the runners and flows made up, the top box fastened down, and the job cast. This method of bedding-in a pattern and moulding was followed out in the days of our great-grandfathers, and is also used by 99 per cent. of moulders to-day.

Turning for the moment to the subject of moulding machines, we may enquire as to the principles upon which they are worked. Taking the jarring machine, the principle of this machine is to compress the sand around the pattern by concussion. This effect is got by working a large piston or plunger rapidly up and down in a cylinder by means of compressed air. Connected with the plunger is a large base plate, rigidly fixed to the head of the plunger. The pattern and moulding-box are fixed securely on this base plate. The facing sand is then placed around the pattern with any strengthening iron which may be thought necessary. Then the black sand is shovelled in until the pattern is well covered. Then the air is introduced, and the plunger is set in motion. Every down motion of the plunger is stopped very abruptly, which causes the sand to become very closely packed, the machine is stopped, and the box is now filled with sand well above the top bars. The air valve is again opened, and after a number of sharp concussions has been given the air is cut off and the operation of ramming the box is finished by a handy labourer with the flat-rammer. The pattern is then vigorously shaken, the box turned over, and the pattern may be drawn either by the machine or by hand.

In another kind of machine the ramming is done by direct compression; the sand in the box is squeezed into a compact mass in one operation. It is, however, necessary at times to give this class of machine a little help with the pin-rammer before the squeezing operation commences, just as it is necessary to help the jarring machine with the flat-rammer.

It will be noticed that in the first machine a pin-rammer is not supposed to be used, and in the second the flat-rammer is never used, but the aim and object of all machines is to do away with the laborious process of pin and flat ramming a mould. Now, it is not always within the power of the foundryman to instal a moulding machine in his foundry, and especially in the jobbing foundry; for the jobs are so varied that it is questionable if a machine could be worked to advantage. But if we cannot have a machine we can work its principles into manual moulding and do away with some of the hard work and make the job quicker and surer. With this idea some 3½ years ago I tried what could be done by pressing with the feet the sand around the plain part of the pattern that had been bedded into the ground, using the pin-rammer only for the small recesses. After a number of quiet experiments I found that the job could be rammed by this method easier and surer and in nearly every case quicker than by the old method of pin-ramming. In the course of time it was found that by pressing the facing-sand well into the small recesses of the pattern the mould could be rammed with the feet up to the parting without the aid of the pin-rammer at all, and should the job be 6in. or 8in. deep the only time a rammer was wanted was when the parting was reached, which had to be flat-jammed every time in the usual way.

The great difficulty in introducing a new system is to get it accepted by the men in the trade, and I find that when a man gets over 40 it is generally almost impossible to get him out of the rut he has been travelling in. In introducing this method to men in our shop I was surprised to hear one say, "Yor wey's alreet, Mr. Gallon, but de ye kna' this—if ah was to gan intive anuther shop and dein' that the gaffer would give us the sack." If this is so, it is a very deplorable fact, for no foreman should condemn any system before he has seen it tried. This system of moulding when bedding-in a job could be tried on a shallow job first, then on a deeper job, and by exercising the same care as when pin-ramming one can safely ram up a job with the feet and the flat-rammer up to 18 in. deep.

Coming to the details of the method, we will assume the hole has been dug to receive the pattern before the bed has been made. In explaining the art of making the bed it will be necessary to refer again to the old methods, as it is here that a great saving of time and labour can be accomplished. The old-fashioned moulder digs the hole 8in. or 4in.

* Abstract of Paper read before the Newcastle-on-Tyne Branch of the British Foundrymen's Association.

deeper than the pattern and then riddles sand into the hole to the depth of 3in. or 4in. On this he places a layer of facing-sand 1in. deep, places the pattern on this bed, and knocks it down, then starts to ram it up in the usual way with the pin-rammer and flat-rammer. Now if the pattern should be a large one, say, 8ft. by 6ft., that would entail a hole 9ft. by 7ft. It will be clear that to rough-riddle sand into this hole to the depth of 3in. or 4in. entails a considerable amount of work without considering the amount of labour required to take out that 3in. or 4in. of sand. My method is to dig a hole about 1½in. deeper than the pattern, then get a garden graip and dig up the bottom similar to the method of digging a garden flower plot. The graip is the best instrument for this purpose. The bed will then be just about the right depth before putting on the facing-sand.

Great care must be taken to make the face of the bed to fit as near as possible the face of the pattern. If the face of the mould has to be vented it must be done now before the facing-sand goes on, and *not* through the face of the mould as in the old system. By this means it is ensured that at least 1in. of sand is above every pricker hole, which makes this part of the process as near fool-proof as possible. It also leaves the mould the proper shape when the pattern is drawn, which saves a lot of unnecessary tool work. When the bed has been properly formed and vented, and the pricker holes stopped up, the facing-sand is put on and the pattern set on its bed, given a gentle knock down all round, staked, and lifted off again in the usual way. Should the face of the pattern not have touched every part of the bed, all loose places must be made up. The pattern is then replaced, facing-sand built round it, and black sand filled in to the depth of 4in. or 5in. This is trampled down with the feet, then the pattern is knocked down to its proper bed. The moulder then goes round with the flat-rammer, and this process of ramming is repeated about every 6in. of depth that is filled in until the top of the pattern is reached. The parting is formed in the usual way. It will be noted that the pin rammer has been entirely dispensed with in the whole of the bedding-in operation. This is the improvement that I wish to bring before you.

Discussion

The Chairman (Mr. W. Mathews), in opening the discussion, said he had known a pattern of about 7ft. square that could be moulded in green sand pure and simple, without skin-drying. There were some sentences in Mr. Gallon's paper of rather grim significance to him as a pattern maker, and one was the knocking down of a pattern. Bedding-in of patterns in this district was in considerable vogue, but he had always found that the knocking down of patterns into the bed had meant a considerable amount of damage to a pattern, and for that reason that process had been almost entirely dispensed with. He was very glad to hear the vehement protest which Mr. Gallon vented against the abuse of tools in the foundry, and especially with regard to the sleeking of moulds. He considered the moulders in the Tyne district were much given to over-sleeking. It was not good; it was a waste of time, and it also made bad castings. There could be no excuse whatever for scabs on castings. In some foundries he had known moulders make light of scabs on castings and think that it only meant a little more work for the machinist, but he thought emphatically that it was an unforgiveable sin, and if due regard were paid to the running of castings they could be avoided.

Mr. Gallon observed that lots of moulders did not take into consideration the pattern they were knocking down. They saw men trying to knock a pattern down with a hammer that was very much too light for the work. His experience in knocking down a pattern was that as heavy a hammer as possible should be used. One knocked the pattern about much less with a heavy hammer than with a light one. There was more harm done in drawing a pattern than in knocking it down. Of course, the pattern was sometimes not properly made.

Mr. Edward Smith (South Shields) said he supposed the only advantage of Mr. Gallon's suggested improvement was that it entailed a little less labour. He thought it might be an advantage, especially where the ground was very rough. As regarded not using the pin rammer, he did not see much difference so long as the moulder did not put too much sand in when he trod it down. If he put too much sand in and just trod it down he was bound to have swellings on the casting.

Mr. Gallon replied that he put more sand in when treading with the feet than with the pin rammer, or, at all events, equally as much; and if the same care was taken when ramming with the feet as when ramming with the pin rammer better results would be got. Some moulders got near the pattern; in fact, some struck the pattern, and there was a scab as the result. If they rammed the job with their feet they could not strike the pattern to the degree of hardness necessary to cause a scab.

Mr. E. Smith: There is no advantage except the saving of labour?

Mr. Gallon: There is also the advantage of the saving of time, although I do not dwell upon that so much as upon the saving of labour, because pin-ramming for an hour or two is a laborious job. If they could save that, he proceeded, there was no reason why they should not. He instanced how on one job he had done it quicker by his method by two minutes than another man using the old method, and that was on a job lasting only 12 minutes. This might often represent the difference between profit and loss on the work.

Mr. Carmichael (South Shields) said Mr. Gallon had spoken of making a hole and knocking the pattern down. He thought that they should dispense with that system altogether and have no hole at all. It would be decidedly more profitable to have two boxes and turn the job over. Digging out a hole and ramming up was not a satisfactory thing at all. On some jobs a pin rammer must be used because the moulder could not get his toe into certain recesses. When the job was light he should have a box and turn it over. With regard to doing away with the pin rammer, he had seen, in a foundry with probably fifty or sixty men, the pin rammer dispensed with. The men used the shovel and their feet; they could see the men turn the job over and dance on it, although it would often be found that those men were on piece-work. Machines could never be a success unless with a perfect pattern. With regard to the closeness of iron and the causing of scabs, he recalled that a "crank" once made a mould in plaster-of-Paris and had it cast, whereon there was immediately a display of fireworks in the shop. The experiment was not repeated.

Mr. Gallon said he had cast jobs in green sand up to 25 cwt., and the largest column he had dealt with had been 8in. mean diameter.

Mr. James Smith said he knew of some castings which had been made in green sand up to seven and eight tons. He was sure it would surprise men who had never had experience of green-sand moulding to see the work that was being done.

One man who was present had made green-sand castings up to 9 tons, and would probably in the near future make up to even 13 tons. With regard to using the feet he dared say that would be all right on the outside of a plain pattern, but there were some places into which the moulder could not get his feet.

Mr. Wear (South Shields) said he did not suppose that the last speaker would undertake to make a cylinder, a condenser, or the intricate parts belonging to a marine engine, in a green-sand mould. He personally would certainly not like to do it. He instanced the case of a moulder who recently undertook to make some columns, 3 tons 5 cwts., in green sand. The first column was a splendid success, but the second was such an exhibition as they never saw—it had the map of Europe all over it. (Laughter.) The experiment was not repeated. He did not think there was much in Mr. Gallon's contention about saving time or labour. Mr. Carmichael's remarks about turning over in a box was a good idea, but it was expensive, because it would take a man a day to make the box. Neither did he think much of the method of trampling it with the feet.

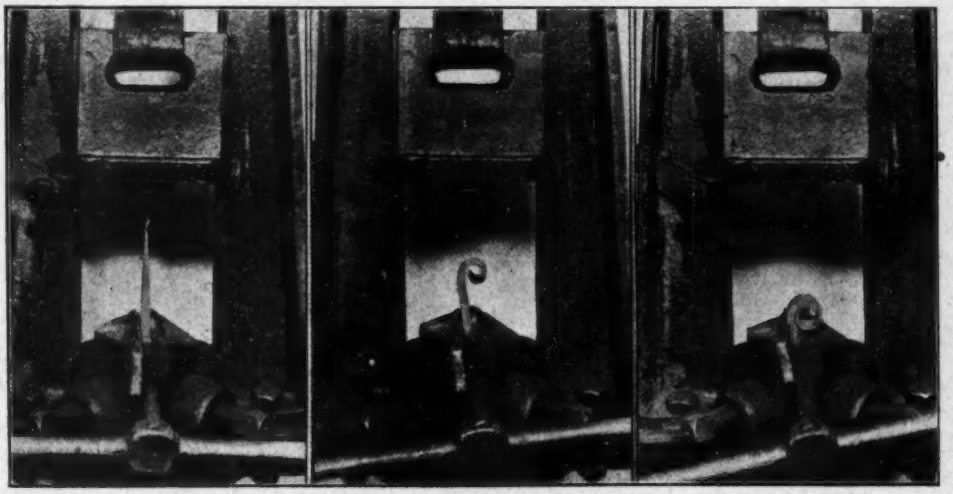
Mr. James Smith, referring to the last speaker's remarks, said he could not see why, if the first column was a success, the second should not also have been a success. The columns in Bradford Station were all made in green-sand moulds without being fired at all. There was a column cast every day, and he thought there would be above 100 columns, but if the hot sand had been used out of the hot bed next morning the result might have been that they would have scabbed. The precaution was taken of tipping the hot sand out at one side of the box and pouring the cold sand in at the other.

Mr. Wear admitted that the second column was put in the same hole, but the hole was not hot.

Mr. Leitch (Darlington) instanced an order for large gas-holder columns 22ft. long, 2ft. 6in. diameter at one end and 20in. at the other. They were cast successfully in green sand. Fire and water would not agree, and if they used a hot hole with green sand they were sure to have fireworks and scabs. There were great advantages to be gained by the study of how to make jobs in green sand; the main item of importance was the running. He did not quite approve of the ramming with the feet and the flat-ramming. He was a great believer in keeping air off the castings, or they would have trouble with scabs. He began with the pin-rammer at the bottom and the flat-rammer after that. Mr. Gallon had said that too much sleeking of the mould face would cause blisters. But it was the air that did not get off the face and would not allow the metal to lie on the face that caused blisters at the bottom.

Mr. Gallon said that with regard to venting through the face it was largely a matter of opinion and experience. Good results could be got from venting through the face. He was of opinion that they could vent through the black sand and get the same result as they could from venting through the face. The improvement was that they did not interfere with the face when they vented through the black sand.

Mr. Gallon was cordially thanked for his contribution.



Wedge-Testing Apparatus, Showing Ductility of Malleable Cast Iron.

Wedge-Testing Apparatus for Malleable-Iron Castings.

The accompanying illustration shows an apparatus for testing the malleability of malleable cast iron, exhibited by the American Malleable Casting Association at the meeting of the Master Car Builders' Association and the Railway Master Mechanics' Association, held at Atlantic City, N.J., U.S.A., recently. A feature of this exhibit was the Walker wedge-testing machine, which strikingly showed the ductility and shock-resisting qualities of malleable iron. This machine is a double hammer which delivers a 70 foot-pound blow. On its anvil is gripped a cast malleable-iron wedge, 6in. long, 1in. wide, ¼in. thick at the bottom and tapering to 1-16in. thick at the top. This wedge receives repeated blows from the hammer. Fig. 1 shows the wedge in position for the test, with its top slightly bent ready for the first blow. In Fig. 2 the wedge is seen after repeated impacts. Although under further blows it completely curled into spiral form it was not broken or cracked. Further tests, in which a wedge which had ¼in. machined from either surface was used, showed identical results, disproving the fallacy that the strength of malleable iron lies in its skin.

The Strength and Properties of Castings.*

By E. L. Rhead, M.Sc.Tech., F.I.C.

Composition.

Many ironfounders and engineers yet fail to appreciate the value or meaning of a chemical analysis which is in nearly every case a mere statement of the proportion of the elements present. The bare statement that cast iron contains certain percentages of carbon, silicon, manganese, phosphorus, sulphur and other elements does not convey any idea of the extent of the amount of the substances other than iron present in the metal.

Of these elements carbon is the only one that occurs in an uncombined state in the metal; of this element a certain amount may separate in the free state, while the rest remains in a state of chemical combination in the metal.

It will be unnecessary to recall that when such a combination between elements takes place the individual properties of the combining elements disappear, and they entirely lose their identity; the substance formed has distinct characteristics and produces effects as an entirely new body. Viewed in this light, the probable character of an iron will be seen to be greatly different than when the amounts of foreign substance present are supposed to be indicated by the percentages shown by the analysis.

Carbon in combination is mainly present as the carbide Fe_3C. As this substance contains only 6.67 per cent. of carbon, the amount of carbide it represents is nearly 15 times the weight of carbon in combination. Silicon is present in combination with iron as FeSi or Fe_2Si, representing three times and twice the weight of silicon present. There is no evidence of the presence of silicon in the free state. Phosphorus is present as a phosphide Fe_3P containing 15.5 per cent. of the element, and equal in amount to 6.5 times the weight of phosphorus. It is all in combination. Sulphur occurs as a sulphide of iron, or of manganese. The former has the composition FeS, containing 36.3 per cent. of sulphur, and nearly three times its own weight of sulphide; the latter has the composition MnS, containing 36.7 per cent. sulphur. Manganese may be present as sulphide or carbide, or merely in solution in the melt. Considered in the light of these facts the following table shows the composition of the cast iron of the analysis stated :—

Percentage Composition.

	Ultimate analysis		Proximate analysis.
Graphite	2.8		2.8 Graphite
Combined Carbon	0.5 (0.5×15) approx.		7.5 Cementite Iron carbide Fe_3C.
Silicon	1.8 (1.8 × 3)	,,	5.4 Silicide Fe_2Si.
Phosphorus	1.0 (1.0 × 6.5)	,,	6.5 Iron Phosphide
Sulphur	0.1 (0.1 × 3)	,,	0.3 Sulphide of Iron
Manganese	0.7		0.7
Total			23.2

NOTE.—The manganese present replacing iron in the compound has been merely added. It does not indicate that it is present in the free state.

Carbon.

Cast iron, when thoroughly molten, contains all its carbon in solution, as far as investigation has shown, as carbide. This lowers the melting point. This carbide is shown in plates on the fractures of highly carburised blister steel. The existence of the carbide depends on conditions. If an alloy of pure iron and carbon only be very slowly cooled from fusion, the whole of the carbon separates in the free state.

In the cooling of carburised metal the indications are that concentration of the carbide, together with other components, takes place as the iron-rich body that first separates is formed.

During solidification of this carbide eutectic the solubility of the carbide rapidly diminishes, free carbide separates and breaks up into graphite, the iron being taken up by the mass. As cooling proceeds the iron-silico-carbide solution solidifies and retains some of the carbide in solid solution. Stead has shown that some silicide passes out with the carbide. The carbide thus retained is not permanently held in solution by the iron, but is separated and undergoes decomposition with a degree of ease dependent upon the amount of silicon present as the metal cools. In high-silicon iron this separation and the dissociation to graphite are almost complete, leaving the basis of the matrix a solid solution of iron silicide in iron. The size of the graphite particles will depend on the ease of diffusion of the substances and the rapidity of the dissociation. Very slow cooling, which prolongs the period of easy diffusion and concentration, leads to the formation of larger carbide plates and graphite flakes. The silicide is also capable of diffusion. With uniform diffusion and decomposition the precipitated graphite will be in small particles more or less uniformly diffused, and does not interfere with the continuity and strength of the structure.

It is not the carbon thus separated that reduces the strength of the casting. The action is similar to that occurring in the production of black-heart castings and to softening castings. In these cases the separation of the graphite which was arrested by the rapid solidification of the iron is allowed to complete itself under the heat treatment. The action of the silicon in effecting this change is shown by the following figures obtained by Charpy and Grenet in annealing experiments :—

Silicon per cent.	Temperature at which C began to separate.
0.07	1150° C.
0.27	1100° C.
0.80	800° C.
1.25	650° C.
2.10	650 C.

In last case 85 % of the carbon changed to temper graphite with six hours heating.

Wüst has stated the eutectic C. solidifies at 1135. If carbide separation occurs in the molten iron the dissociated carbon rises as kish† or remains behind in admixture with a tendency to rise. Very peculiar structures are sometimes met with in cast iron in which a graphite plate forms the middle of a more or less herring-bone structure, the dark parts of which are finer graphite particles resulting from the decomposition of subsidiary plates of carbide. Obviously coarse graphite, by forming planes of cleavage, diminishes the strength of the mass as a whole. It is nevertheless possible for the separation to be as complete in cases where the flakes are individually smaller, and the less they are, the less they will interfere with the continuity of the structure, and tougher and stronger castings will result.

The separation of this graphite has another bear-

* Abstract of Paper read before the Manchester Association of Engineers, January 22, 1916.

† Probably all the kish met with in the foundry is not due to this cause.

ing. Its density is about 2.6, whereas that of the iron at the temperature of its formation varies from 6.8 to 7.2. The increased volume which it occupies does much to counteract shrinkage of the metal, and thus reduce the distortion and the development of internal stresses in the castings.

Combined Carbon.

That portion of the carbide which does not separate as free carbide and decompose to graphite, but is retained by the liquid till it solidifies, behaves exactly as does the carbon in steel and forms a pearlitic mass which behaves exactly in the same way, so far as it is not interfered with by the presence of other elements. In the case of steel the strength rises progressively with each increment of carbon to a maximum in fully-annealed steel, corresponding with 0.89 per cent. carbon. Increase of combined carbon causes a similar increase of strength in cast iron. The rate of increase is less regular owing to the action of other bodies.

In the absence of interfering bodies, the stronger, tougher material filling up the intercrystalline spaces makes the casting stronger in every way, and even chilled specimens lack that brittleness usually associated with white and chilled iron. Such material can be forged to a considerable extent if little or no coarse graphite has separated. The amount of combined carbon in castings is usually low and seldom exceeds 0.7 per cent. In the sequel it will be seen that the retention of much combined carbon is only possible in iron of certain composition. Increase in hardness results from the presence of combined carbon and this increases the difficulty of machining.

Silicon.

The presence of silcides in iron has great influence on its character and behaviour. Baker and Hadfield have shown that in amounts not exceeding 3 per cent. the mechanical properties of iron are not materially altered, being ductile and tough, but the elastic limit and tensile strength are much raised. This applies to pure, almost carbonless, iron, and may be termed the direct effect. Turner's classical work is well known.

In cast iron the indirect effect is the more important. In a melt containing silicides the separation of the carbide occurs more readily and completely, resulting in the formation of more graphite. High-silicon iron contains little or no combined carbon. The silicide appears to have the property of salting out the dissolved or colloidal carbide in the same manner as soap is salted out in soap boiling by means of another soluble body, viz., common salt.

The separation of the combined carbon has a softening effect, the precipitation of graphite reduces the shrinkage and reduces internal stresses. So far as its direct action is effective, and in proportion as it relieves internal stresses, its action must be to increase the strength of the castings; but when the amount present is such that the graphite separates either in increased quantity or larger flakes and tends to produce an equal reduction in strength, the limit of its advantageous application in strong cast irons has been reached. The amount capable of doing this will vary with the composition of the iron. There is little doubt that substances that lower the melting point and prolong the solidifying stage do in general promote the carbon separation and the growth of larger graphite, with the necessity of restricting the amount of silicon.

Interesting results were obtained by Hadfield in a series of experiments on iron carbon alloys, containing varving proportions of Si. The experiments indicated that when a certain amount of silicide is present the iron is no longer able to retain the carbide in solution.

Frequently in dealing with irons low in phosphorus, sulphur, and manganese, very small variations in the silicon in the neighbourhood of 1 per cent. in large castings, have an enormous influence on the structure, changing it completely from a fine to a coarse grain, or *vice versa*. It would appear possible that the amount necessary to procure precipitation of graphite coincided with a certain concentration of the solution, as frequently occurs in other cases, and that the reason for the smaller amount having the same effect in thicker castings is due to the slower cooling affording greater facilities for diffusion and concentration. When the solution becomes rich enough in silicides separation and precipitation of the graphite proceeds and the grain becomes open. In that case the initial temperature of the mass and the rate of cooling will exert very great influence on the concentration of the silicides by the withdrawal of the iron-rich body and thus on the grain and strength of the metal, and incidentally on the internal stresses and liability to spontaneous fracture while cooling, or subsequently. It is probably in this region that many of the vagaries of metal and unexplained causes of fracture must be sought.

In presence of other bodies such as phosphides, the proportion of silicon necessary to produce carbide saturation and precipitation is less, and hence the completeness of the graphite precipitation and reduction in shrinkage that is secured with such irons.

It has been frequently stated that in some cases irons cast at high temperature have a tendency to be closer and stronger than those cast at a lower temperature. The author's experience has been that the greyness of the iron cast at the lower temperature is of quite a different order. The lack of strength may be ascribed to the fact that before pouring, the complete solubility had ceased to exist; the various components of the metal were no longer in perfect solution in each other. The metal may have passed through stages of liquid crystallisation which are subsequently broken up and cannot be reformed or resumed at the lower temperature, or some of the products of the final crystallisation may have assumed a colloidal state, and being subsequently mixed up in the pouring, form an emulsion with the remaining fluid, preventing it from following the ordinary process of solidification. It is also certain that in some cases actual separation of solid matter has begun, as in the case of iron throwing up kish.

All cases of kishy irons must not be attributed to the fall in temperature of the metal. There is every probability that in melting in the cupola some of the graphite is not redissolved by the iron, and the metal, as it runs from the cupola, contains free graphite which rises in the ladle. Such graphite interferes with the development of structure and gives rise to other difficulties, all of which tend to lower the strength of the casting. For example, they form solid attachments for gas which may form blow holes or gas films, and probably lead to formation of larger flakes than would otherwise be the case, as by acting as nuclei the rest of the graphite may be deposited on it much in the same way as solids placed in crystallising liquids receive the crystals formed. For these reasons probably test bars and castings run at high temperatures have greater strength than those run at lower temperatures.

As to what is the correct temperature at which to pour a casting, obviously it is impossible to state any definite temperature that will apply to all cases, as regard must be paid to so many different factors—not only to the nature of the metal, but to the size of the casting, the length of time it will take to pour,

the fluid contraction and final shrinkage among others.

It may be laid down that the most suitable temperature for casting is that which will allow the mould to be completely filled with molten metal, which, when the mould is full, still retains all its constituents in completely fluid solution, and all preparations as regards metal and gates must be made to that end. It is not only unnecessary but inadvisable to heat the metal beyond that temperature, since the longer period of setting prolongs the period during which the casting is weak, gives opportunity for the formation of coarser graphite, and the formation and transference of the most fusible eutectic possible in the iron used, with the formation of shrink holes and local weakening where it has been withdrawn.

With the knowledge of the advantages in strength which result from the rapid cooling of castings, whether by the use of specially designed chilling plates, or by accelerating it in other ways, the author suggests that those castings are weakest in which, from any cause, the separation of iron-carbide or graphite precedes the proper development of crystallisation in the mass. In the many examples of strong iron that have come under the author's notice, in which similar materials have yielded widely different results, those giving the higher figures have had this crystalline development, and those giving the lower figures have been confused, or in some cases almost striated when microscopically examined.

From these considerations it would appear that for every type of metal and for every casting there is an ideal pouring temperature at which the slowness of the cooling shall not lead to the separation of coarse graphite with consequent loss of strength.

Phosphorus.

Phosphide of iron is the most fusible constituent in the iron. It is also the hardest, and is very brittle. In cast iron it forms with other compounds present a very fusible eutectic, which only solidifies at about 950 deg. C. The phosphide of iron, Fe_3P, is a highly crystalline body, and when in large excess, itself forms crystals belonging to the monoclinic system—quite distinct from iron, whose crystals belong to the cubic system.

Stead has shown that, calculated as Fe_3P, pure iron is capable of retaining in solid solution (*i.e.*, without any new microscopic constituent making its appearance) 1.7 per cent. of phosphorus. This would correspond to nearly 11 per cent. of the phosphide. With larger amounts the phosphide separates as a eutectic with a melting point of 980 deg. He further found that the presence of carbon caused the separation of the phosphide as a eutectic.

In cast iron which is both highly carburised and siliconised there is no doubt of the complete separation of the phosphide eutectic. As little as 0.1 or 0.2 per cent. of phosphorus produces a eutectic that can be found on microscopic examination as a distinct body, and the amount increases as the proportion of phosphide increases.

There is evidence to show that the presence of phosphorus actually lowers the total carbon contents of iron, but the amount present in foundry irons does not seriously reduce the percentage of carbon. Such irons always exhibit a lighter colour, with the same carbon contents, as less phosphoric iron of otherwise similar composition, but this is due to the whiteness of the eutectic which they contain.

The low melting point of the eutectic permits crystallisation to proceed freely. In castings containing 1.5 per cent. of phosphorus the author has found the eutectic to contain 6.55 per cent. of the element, corresponding to 23 per cent. of the eutectic. Further additions tended to raise the melting point. This eutectic has a melting point of 950 deg. C. The temperature at which separation commences is uncertain, but irons that contain very small amounts and whose solidification is practically completed at high temperatures show the presence of separate phosphide eutectic.

Influence of the Phosphorus.

So long as the phosphide remains uniformly dissolved its effect on lowering the solidifying temperature is general. If the carbon saturation be high and the silicon contents be also high, a point may be reached at which temperature the carbide may be precipitated, decomposing into graphite as previously stated, the graphite growing in size as long as free movement is possible. These graphite flakes interfere with and prevent the development of a structurally strong arrangement and crystallisation.

Several writers have called attention to the great variation of strength in phosphoric iron. Cook stated that when phosphoric irons had a meshed structure they were strong, and when they had a confused structure they were weak, and concluded that the phosphorus either raised or at least did not lower the strength of the metal. The true explanation, we submit, lies in the fact that in irons presenting the meshed structure the normal growth of iron-rich crystals has proceeded prior to the saturation point of the carbide being reached, the growth of objectionable graphite crystals has not occurred, and the internal structure has been mechanically sound. That this is the course of procedure appears probable from the manner in which phosphide pellets are formed. The fused eutectic is forced from between the inter-crystalline spaces by the contraction of the interlocking crystals which have at that temperature developed a strength which resists fracture and ensures continuity.

The bigger the casting, involving the slower cooling and consequently greater activity of the silicon and carbon, the smaller should be the proportion of these constituents within the bounds of the possibilities of making the castings. This is borne out in the series of test bars, of which the following are the particulars :—

No.	Sizes of Test Bars.	Length between supports.	Transverse load.	Silicon.	Manganese.	Phosphorus.
1.	2 × 1	36	30	1.9	0.4	1.0
2.	,,	,,	34.5	1.8	0.4	0.7
3.	,,	,,	37.5	1.6	0.7	0.5
4.	,,	,,	40	1.4	0.7	0.5
5.	,,	,,	43	1.3	0.9	0.3
6.	,,	,,	45.75	1.2	1.0	0.25
7.	,,	,,	29	1.0	0.8	0.6
8.	,,	,,	21	0.9	0.4	0.15

To obtain strong, tough, sound castings the phosphorus contents must be as low as possible. This especially applies to large castings required for heat-resisting purposes. Its effect on the strength is shown by No. 7 bar. For the latter purpose the low melting point of the eutectic is the drawback. No. 8 showed chill, and to that the reduction in strength is attributable. Sharp chill invariably reduces strength. In these cases the casting conditions were unsatisfactory for the iron for such sections, and probably in larger sections very strong castings might have been attained.

The advantages of low-carbon, low-silicon, low-phosphorus iron for strong castings are generally recognised by the improvement in strength resulting from the addition of wrought iron and steel scrap to the cupola charge—the so-called semi-steel of the ironfounder. These additions all tend in the directions indicated, and their success depends on establishing the conditions laid down, the most important of which are melting at such a high temperature that the pig-iron and steel become perfectly dissolved. Low melting point irons are unsuitable

on account of the disparity in their melting points. Melting at the minimum possible temperature is liable to produce an unsatisfactory result, due to components beginning to fall out of solution before the pouring is complete and the mould filled.

Brittleness.

The phosphoric eutectic is very brittle and hard. It has no toughness or ductility, hence the low resistance to shock of phosphoric irons, especially those of irregular structure. As a further result of the fusibility and fluidity of the eutectic the formation of shrink holes in phosphoric iron is very common. They result from the shrinkage of the metal in passing from the liquid to the solid state exceeding the expansion resulting from the separation of graphite plus the solid contraction of the casting as a whole. The fluid eutectic sinks away by gravity to keep the lower part of the mould filled. Where they occur they weaken the casting as well as increase its porosity.

There is a further effect on the strength of castings to be considered. Even in cases where silicon and carbon contents are low, and phosphorus is relatively high, the effect of the element is exerted through the whole mass, lowering the melting point, and prolonging the solidification period. Wherever this occurs, from whatever cause, the weakening effects resulting from the development of internal stresses caused by the slower cooling of thicker parts are accentuated, as also are those resulting from the presence of hard cores. The greater fall of temperature before solidification is complete inevitably means greater contraction, and the semi-solid metal is weak, and stresses or fracture will result.

In the light of these considerations the disputes so often raised as to the advantage or otherwise of feeding castings, and providing risers, will be intelligible. What would yield a better result in one case may fail to do so in another when the metal has a different composition. It can only provide against fluid contraction, the liquid pressure of the head forcing the liquid to follow every phase of the solidification and maintain the mould full. In the absence of such pressure any gas that separates may form films on the developing solid and prevent the perfect cohesion of the mass. In worse cases it may form bubbles and occur as blow-holes.

For thin castings of uniform section where solidification is completed rapidly the ill-effects of phosphorus do not appear, and the improvements noted in castings where the use of chilling plates is resorted to are due to the prevention of such separation as will make the structure coarsely granular by the separation of the components. The effect of the chilling plates is to cause the solidification in that region to proceed with such rapidity that it is completed while the metal in the head is sufficiently fluid to follow the contraction and feed the casting. When used smaller heads are necessary. The retention of some of the constituents, *e.g.*, carbon in the solution acts also directly as a means of increasing the strength. These chilling plates act by causing the removal of heat to be more rapid from parts that would otherwise remain hot and either serve as feeders for thinner parts at a lower level in the mould or become graphitised by slow cooling.

Manganese.

The effects of this element may be thus summarised:—It lowers the melting point to a small extent and increases the fluidity of the metal. Being a metallic element its behaviour is different from those considered. It resembles iron, and forms carbides, sulphides, silicides, phosphides, etc., in the same way. These compounds are, however, more stable at high temperatures than the corresponding iron compounds. Its distribution and mode of existence in the metal varies. It may exist as part of any iron formation so long as saturation be not reached. It is accordingly found associated with the carbide, the silico-ferrite, and as sulphide.

Manganese decomposes both sulphide and oxide of iron. The familiar "break" on molten iron is much more pronounced in iron containing manganese probably due to elimination of gas and the convection currents arising from the increased density of the upper and cooler layer. When cast under proper conditions of temperature the increased soundness and freedom from blow-holes is thus explained.

Manganiferous irons usually contain more carbon. Thus spiegel and ferro-manganese contain from 6 to 7 per cent. This increase is due to the presence of the manganese, and the whole of the carbon is in combination as carbide. Its presence in foundry irons under similar conditions has the same effect. This has been the author's repeated experience. Two examples are given below:—

Graphite.	Combined Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.
2.65 ..	0.31 ..	3.27 ..	1.64 ..	1.58 ..	0.09
3.2 ..	0.13 ..	2.96 ..	0.29 ..	1.4 ..	0.11

Despite the higher silicon and lower sulphur contents the combined carbon is much higher. The manganese is the only element responsible for the difference. This may be taken as a type. Not only is the tendency to retain carbon greater, the pearlite formed is much more finely laminated. The author has invariably found that the hardness increases and ascribes the effect largely to the increase of combined carbon. Some of the increase is due to the manganese remaining in solution in the silico-ferrite. The tensile strength and elasticity are increased, and the iron machines with a fine smooth surface, and may be readily glazed. West's figures tend to show that its effects are greatest in high silicon iron where the presence of that element would tend to lead to the graphitisation of the metal most readily. With more than 2 per cent. of manganese the hardness increases rapidly.

Sulphur.

This element occurs principally as sulphides of iron and manganese. It has in some way the effect of preventing the separation and decomposition of the carbide, but at the same time lowering the solubility of the carbide. Sulphur added to molten cast iron causes it to throw up a sooty coating. This carbonaceous matter is the product of displaced carbide. The sooty material contains also sulphide of manganese.

This displacement of carbide prevents or reduces the possibility of graphitisation, and this increases the probability of whiter and drawn castings. The pasty stage is prolonged, and all the troubles arising from contraction during this stage are accentuated. The exact form in which the sulphur is taken up is now under investigation in the author's laboratory, and some progress has been made. The retention of a larger proportion of combined carbon makes the metal harder and more brittle. It does not follow that the tensile or transverse strength of the metal is reduced if soundness be attained, but this is difficult, and drawn castings are inevitable if much be present.

This applies only to the sulphides remaining in solution, or as double compounds in the metal. Pure iron free from silicon and manganese can retain sulphides equal to 0.8 per cent., *i.e.*, nearly 2 per cent. of sulphide of iron. If the sulphides be thrown out of solution and segregated from the metal the effect is minimised. Manganese has the effect of causing

this segregation. It consequently exerts a dual effect. Its addition to sulphury irons renders the metal softer and reduces the tendency to draw, and the troubles resulting from these causes. The amount necessary to produce this effect varies with other components. In ordinary grey irons the amount varies from 0.5 to 0.7 per cent., the larger quantities being required in the harder irons containing less silicon, the danger of the hardness being increased by the manganese added only applies when the amount is excessive.

Very small additions of sulphur produce serious changes in the metal for making soft castings, and the effect of silicon is rapidly neutralised. Many of the vagaries occurring in practice in connection with the addition of silicon are due to this being overlooked. The increase in the sulphur contents of the metal during melting are most responsible. This in turn depends on the sulphur in the coke, and the temperature of melting. Metal melted hot and rapidly takes up less sulphur than when melted at lower temperatures and slowly.

The increased porosity of castings in iron containing sulphur appears to be due either to the greater solubility of gases when in the molten state which are given out on cooling or to the fact that the metal cannot retain as much when in the solid state as is usually present.

The diminution in the amount of graphite liberated accounts for the greater tendency to produce warped, drawn and unreliable castings, and also at the same time for the increase in strength sometimes noted with a small increase of sulphur. The sulphide to produce this effect must remain in solution in the metal, and the effect may be neutralised by the presence of manganese.

Core-Making and Sand Binders.

At a meeting of the Lancashire Branch of the British Foundrymen's Association, held at Manchester on January 8, Mr. J. G. Robinson read a Paper on "Core-making and Sand Binders," which he had previously given before the Birmingham Branch at their December meeting. (See F.T.J., January.)

At the close of the paper,

Mr. Cordingley said that in using oil-sand cores he had experienced certain difficulties with pitting, but some of the suggestions made by Mr. Robinson would assist him in overcoming them. Did the Lecturer recommend any particular sand—river-bed or sea sand?

Mr. Sherburn said he should be interested to hear what arrangements were made for carrying the bomb cores while they were soft.

Mr. Sidney Smith found himself in agreement on nearly every point with Mr. Robinson, and had made bomb cores exactly in the way described by him. With regard to the objectionable fumes which most, if not all, of them had experienced, especially when there was an excess of oil in the mixture, he had discovered much less oil need be used. Cores made with gas tar set so hard that nothing much less than a steam hammer would break them.

Mr. Key said that as the outcome of his own experience, he gave the preference to clay-bonded as against oil-sands, if the expense and all other matters were considered. That was especially the case in regard to the making of irregular cores; for plain cores they still used oil sands in the foundry where he was engaged. The principal difficulty was in keeping the core to its shape. They had great trouble in getting the sand mixture correct; his own method was to dry the sand first, then mix the oil thoroughly with the sand and add the moisture according to the class of core to be made. The existing prices of oil of course rendered oil-sand cores very expensive, while the cost of material for the ordinary core sand was but little. Some time ago he had a lot of cores with Diesel heads through his hands; they used to be made with ordinary core sand, with a slight proportion of molasses added. They had no difficulty in making the cores.

Mr. Bickerton said he had tried oil sand as an experiment with one or two cores, but found a special kind of tackle was needed in handling them. If once, however, the expense were got over he should think it would pay for itself in time. He did not understand how Mr. Robinson fastened the bottom part of the bomb core to the top—whether he had a screw, or how he put them together.

Mr. Roe remarked that linseed oil was costly, and he could not see any advantage over the use of ordinary clay-bonded sand.

Mr. Robinson, in answer to Mr. Cordingley, said they got their sand from Birkdale (Southport), the cost being one shilling per ton on the trucks. Sand from the floor would not do; it was a mistake to think of using any sand of that kind with oil, because the oil would neutralise the clay in the first place in the clay-bonded sand, for if clay bond were used with oil it reduced its effect. With an oil binder sea sand was the most suitable. They could use chills with oil-sand cores. While the bomb cores were soft they were carried on cast-iron plates with holes in them. Baking and drying were merely a matter of experience; there was always a way of telling whether they were dry or not by pushing the point of a knife in. With regard to mixing, while the better method was to mix the oil and sand first, generally speaking, yet if they had in the shop a machine for emulsifying the oil and water then the two might preferably be mixed with the sand in one operation. To the speaker who stated that he had a preference for clay-bonded sand he could only say that the preference was an expensive one; there was no need to be afraid of the cost of oil-sand; in fact, there was no comparison whatever in the cost of fettling. It was all a matter of tackle to make oil-sand cores satisfactorily. It was quite right to mix the oil with the dry sand; it was the best way to use it.

PRESERVATION OF IRON PATTERNS.—A method of preserving iron patterns from rust and corrosion used by one founder is first to subject them to an air blast to remove dirt and dust, and then to immerse them in a pickle composed of 5 gal. of water and 1 pt. of sulphuric acid; this is used hot, and the patterns are allowed to remain in it for 5 min. The patterns are then rinsed in water and dipped into a hot potash solution made by dissolving 1 lb. of potash in 1 gal. of water; this neutralises the acid left in the pores of the iron. The patterns are allowed to remain in the solution for about 5 min., and are then scoured with a stiff brush to remove the rust and again dipped into the sulphuric acid for a minute or so. They are then rinsed in *cold* water and not allowed to dry, afterwards being immersed in a weak cyanide of potassium solution made by dissolving 2 oz. of the cyanide in 1 gal. of water. They are then copper-plated in the regular cyanide copper-plating solution used by all electroplaters. The solution is used hot, and the deposit need not be thick, the time necessary being usually from 5 to 10 mins. The next step is to rinse and dry the patterns, after which they are warmed and paraffin wax rubbed over the surface as a thin coating. When cool, the surface is brushed with a bristle brush in order to smooth down and even the paraffin coating. They are then ready for use. The paraffin protects the copper from corrosion and allows the pattern to leave the sand easily.

British Foundrymen's Association.

Sheffield Branch.

At the recent annual meeting of the Sheffield Branch of the British Foundrymen's Association, when Mr. T. H. Firth presided, the annual report showed that at present there were on the register a total of 134, consisting of 39 members, 77 associate members, and 18 associates. The following were elected officers for 1916:—President, Mr. John Little; Vice-Presidents, Mr. J. G. Crowther and Dr. Hatfield; Auditors, Mr. W. Oxley and Mr. J. R. Hyde; Committee, Mr. Darley, Mr. Webster, Dr. Longmuir, and Mr. Pilkington; Secretary, Mr. J. Dickinson.

The annual business was followed by the reading of an illustrated paper, entitled "A Day in a Foundry," by Mr. J. G. Robinson, of the Campbell Gas Engine Company, Halifax. The paper had previously been delivered in Birmingham, and an abstract of it appeared in our issue of May, 1914. At the Sheffield meeting it was followed by a discussion in which several points of interest were raised.

Mr. Green referred to the lecturer's remark that when he got metal down from the ladle he liked to get it down hot, and that if it was hot the addition of "physic" was quite unnecessary. That was very good as far as it went. When metal was hot it was satisfactory, but "physic" was a very good addition to some kinds of metal. Heat in the metal would not eliminate the sulphur, whereas the addition, say, of a small portion of manganese would do so. In certain classes of work the elimination of the sulphur was practically essential.

Mr. J. R. Hyde spoke of the use of soft metal for a piston and hard metal for the ring, which the lecturer had suggested. He said that was really an engineer's proposition. The piston rings were not supposed to carry the weight of the piston. The problem of unequal heating was also involved in the matter. The cylinder walls were water-jacketed, and consequently their temperature seldom got above the temperature of the boiling water, but the piston had the hot gases behind it all the time, and it was nothing exceptional for it to get practically red-hot in the middle. He should supply the engineer with a fairly hard metal, possibly No. 4, and leave him to deal with the siezing-up. The foundry was really called upon to supply good wearing metal for both cylinder and piston. He experimented in this matter some ten years ago in making a new piston for a gas engine. He tried soft metal, but found that it wore out very quickly, and on substituting hard metal, got a very much more satisfactory result. Mr. Robinson was dealing with a much bigger piston. His (the speaker's) was 7 in., while Mr. Robinson's, he took it, was 14 in. or even 20 in., in which case the difficulty was more marked. Could the lecturer give him any idea of the approximate cost of running drying stoves for a 13-ton flywheel of which he had spoken? He would like to know the coke consumption per night. They would have to make their own additions as to the value of the labourer's time in looking after the stoves.

Mr. T. H. Firth said that seven or eight years ago he went round two or three foundries in the Glasgow district and saw drying stoves working very successfully, but when he got back to Sheffield, instead of having his own way, as he expected, he found that the foreman did not seem to want the stoves, and they had still gone on in the same old-fashioned way. But there was no doubt that the stoves saved a very big expense in first cost and were very much cleaner. Had he correctly understood Mr. Robinson to say that two stoves would dry the 13-ton flywheel in one night? The lecturer had also stated that when they had blacked the flywheel with blacking they rubbed in some plumbago afterwards. He knew that was done very often in the case of small castings, but he was not aware that it was adopted with castings of the size referred to. At one of their Sheffield foundries, where light castings were made, plumbago was used, and better castings were made there than at some of their other works. Mr. Robinson had also referred to the use of a Jones and Attwood core machine. Did he understand that if they got an order for a 9-in. pipe, 9 ft. long, at lunch time, they cast the pipe the same day? Did they make the core with the machine, without any blacking, skin-drying, or anything else being required?

Mr. F. Darley asked about chills on cores, and whether the lecturer did not experience difficulty with the contraction when they were made in halves. He should have expected the liner to crack. As to the difference in expansion of hard and soft metal, he had proved that in steel as well as in iron the harder it was the greater the contraction.

Mr. Robinson, in reply, agreed with Mr. Green as to manganese eliminating sulphur. He said that if an iron with an excess of sulphur was melted hot the sulphur would always rise to the top of the ladle. Ferro-manganese was the only "physic" that he used in the foundry. His particular work did not require a soft iron as a general rule, so that the addition of manganese was not detrimental; it increased the hardness and the wearing properties of cast iron. Manganese added to iron in the shape of ferro-manganese would tend to eliminate the sulphur, but, so far as the sulphur removal was concerned, in any casting hot iron was far preferable to the addition of ferro-manganese. During the coal strike they were having great difficulty owing to castings being hard and having white spots, due to excess of sulphur in the coke; so in every ladle he put, according to the quality of iron required, 10 lb. to 20 lb. of ferro-manganese before the metal was tapped into it. By doing that and letting the metal stand a few minutes the sulphur was cleaned out, the manganese taking it up and causing it to rise on the top of the ladle as manganese-sulphide. Mr. Hyde had said that piston rings were not supposed to carry the pistons. He did not quite agree with that, because wherever they had a piston ring on a piston it was of bigger diameter than the piston itself, so that it must be running on the liner, and he considered himself that a piston was floating on the rings inside the liner. Mr. Hyde mentioned that the liner was water-cooled, whereas the piston was not. Well, all their large pistons were water-cooled as well as the liner, so they should have an equal rate of expansion according to the heat which was generated both in the piston and in the liner. He agreed with Mr. Hyde as to the use of No. 4 iron. If there was much difference in the contraction of the two irons there would be a corresponding difference in the rate of expansion when heated, so that if the piston was of a soft material and the liner of a hard material one would expand more than the other. With regard to the cost of drying moulds with portable stoves, they used about 1½ cwt. of gas coke on the small stoves and 3 cwt. on the large stoves, so that two stoves burning 1½ cwt. each during the night would dry a mould

for the flywheel. For practically any mould that they made, either a flywheel or a horizontal gas-engine bed, they used two pans. Below that size they only used one pan for drying during the night.

The drying might only appear to be skin drying, but it really went four or five inches into the mould. It was not feasible to calculate the cost of drying at so much per ton, seeing that the same stoves which would dry a two-ton casting would also dry one of 13 tons. He did not think it was better to use furnace coke than gas coke; furnace coke required rather high pressure. With regard to plumbago on the flywheel, this was used simply on the arm cores. When the metal was poured into the boss all that got into the rim had to flow through the arms, and there must be something to resist the heat of the metal. Just over the end of the arms these cores were sprigged in addition to being blacked, but after being blacked they were dusted with plumbago, which was rubbed well on and gave a very clean casting.

With regard to the Jones and Attwood core machine, Mr. Firth was quite right in his supposition that an order for a 9-in. pipe, 9 ft. long, received at, say, two o'clock in the afternoon could always be cast the same afternoon, because there was only a matter of half an inch of sand on the core barrels. The core barrel was rotated by mechanical means and the sand was moist. The makers of the machine advised that after the sand had gone through it should be put in without any blacking or anything, but he preferred to dust it over with plumbago and put it in the stove and really dry it. Mr. Darley mentioned the chill on the cores and the difficulty in making them in halves. They had had difficulty, but it was not in the direction which Mr. Darley suggested. Mr. Darley said it might crack the castings. The chills with which they had had difficulty were only a matter of five-eighths of an inch thick. They were put on the core in halves; when the pressure came on, with having that chill in halves, they split or parted at the half, and when the compression came on the casting, through the nip, owing to the contraction, it nipped them in on the loose end. The metal had not solidified by that time, and it pressed them out the other way, and an elliptical casting in the opposite direction was got through having a loose end where the chill was split.

A vote of thanks was accorded to the lecturer, on the motion of Mr. FIRTH, seconded by Mr. YEARDLEY.

The Decay of Metals.

At a joint meeting of the Sheffield branch of the British Foundrymen's Association, the Sheffield Society of Applied Metallurgy and the Sheffield Society of Engineers, which was held in the University on January 28, Dr. Cecil H. Desch, of Glasgow University, lectured on "The Decay of Metals." Dr. W. E. S. Turner (President of the Society of Applied Metallurgy) occupied the chair.

Dr. DESCH did not deal with the simpler forms of corrosion, such as ordinary rusting of the surface, or the solution of metals by acids, but with the decay due to internal disintegration, recrystallisation, and corrosion by chemical agents. He illustrated the first case by the tin plague—the effect of a low temperature in turning tin from a white and fairly tough metal into something grey and entirely brittle, which often, in course of time, decayed into a grey powder. Recrystallisation under the influence of heat took place in most metals, though generally not to a very alarming extent. The crystals might grow without very greatly weakening the metal. In the case of steel, more particularly, they might see this growth taking place in certain abnormal cases in such a way as to give rise to enormously large crystals. That happened if they had the metal heated for a long time at the temperature most favourable to the growth of the crystals—that was to say, slightly below the critical point. Sometimes some rather curious results were got. He exhibited a remarkable slide of a very mild steel guide-rod, which had been kept for a long time at a temperature favourable to the growth of crystals. He quoted striking examples of the graphitisation of grey iron pipes buried in the ground, and of the decay of Muntz-metal bolts, converted by the action of sea water into masses of spongy copper, retaining the original shape. The method of studying corrosion by means of electrolytic experiments was discussed.

Dr. W. H. HATFIELD, in the course of the discussion which followed the lecture, referred to the slide depicting the guide-rod, which showed a number of very small crystals in the centre of the bar, with the large crystals ranged round the exterior. Dr. Desch exhibited that as an instance of a new crystalline arrangement brought about by exposure to the higher temperatures. It would be extremely interesting if he would give them his explanation as to the growth of the large crystals. He (the speaker) presumed that he would explain that they were due to the work that had been done upon the outer portions of the bar. Dr. Desch had beautifully illustrated that right through the whole of the metals and alloys which he had dealt with the corrosion or decay had taken place along the crystalline junctions, and had also indicated the influence which twinning had. With regard to the corrosion of cast iron, some little time ago he examined a cast-iron tube which had been in the ground for about a hundred years. The corrosion had eaten half way through the metal, and it was most interesting to see, standing out amidst the corroded metal, the phosphide, which did not seem to be attacked at the same time as the iron. Dr. Desch had explained how the segregation of gas might cause a separation of the layers of the metal in the case of nickel. Personally, it seemed to him very difficult to believe that the gas could segregate in that manner. In the first place, they knew very little about the manner in which the gas actually existed in the metal, and he should certainly require a great deal more evidence before he was prepared to agree that they could have this local segregation.

Dr. DESCH, in the course of his reply, said that no doubt the immediate reason of the large crystals round the side of the rod was the existence of a certain amount of work at the outside. But why the growth should take place up to a certain limit, and then stop short, was much more difficult to explain. However, it was a fact, and a fact that was now fairly well known. If a metal, such as copper, having certain definite crystalline sizes were scratched on the surface and then annealed gently, on both sides of the scratch would be found a line of quite small new crystals, very much smaller than the other crystals. If annealing were continued, these small crystals grew, swallowing up the neighbouring crystals until they became much larger than the ordinary crystalline size of the metal. They reached a certain limit and then stopped, and there was always a sharp boundary between the large crystals and the small ones. He thought perhaps an explanation might be given. Dr. Burgess, of America, had shown that a certain amount of deformation was required before crystals of iron would grow, and he thought it was

connected with that. As regarded the graphitisation of iron, it was the fact that phosphide remained intact; so also did any massive cementite. He thought there was no difficulty in imagining how gas in solution could segregate. It must be remembered that metals such as nickel were cooled down fairly rapidly from the molten state, and they very easily remained super-saturated with gas. They dissolved more gas than corresponded with equilibrium at the ordinary temperature. In the process of slow heating, that gas came out of solution which could not escape freely. It had to find its way out somehow, and it did so by means of the space between the crystals. Supposing there to be an amorphous layer there, then in all probability the solubility of the gas in the amorphous material would be greater than the solubility in the crystalline, and that would lead it to choose that path to get out.

The Orth Open-Hearth Furnace Roof.

A considerable extension of service is said to be obtained from open-hearth furnace roofs by the use of the Orth method of reinforced construction. Reports to hand show that the average number of heats per roof increased from 387 with ordinary construction to 537 with the reinforced roof.

As indicated in the cross-sectional view (Fig. 1), the arch is built preferably with ribs of special brick shapes having a depth usually from 3 to 6 in.

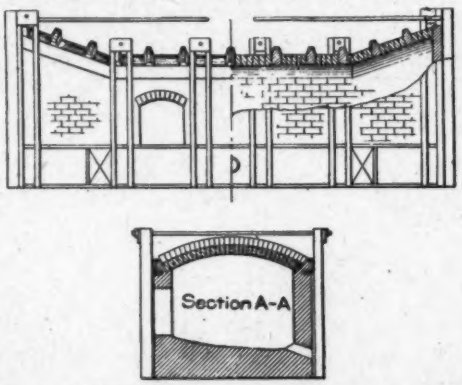


FIG. 1.—REINFORCED ARCH CONSTRUCTION FOR OPEN-HEARTH FURNACE ROOFS.

greater than the regular roof brick. In some instances the construction is simplified to the point of alternating courses of 9 and 12 in. brick. These ribs, spaced at centres varying from 24 to 36 in., are relied upon to take practically all of the transverse thrust through the roof, also supporting to a considerable extent the intervening brick courses. With the furnace roof relieved of the function of supporting itself, the extent to which it may safely be permitted to be burned away is increased. It is stated that the ordinary furnace roof must be replaced when no more than an average of 30 per cent. of its thickness is burned away, largely for the reason that the burning of the roof is excessive in patches, developing thin spots over an area, which, though limited, endangers the entire roof. With the reinforced roof construction the average burning away of the roof, it is claimed, is brought up to 60 per cent., and roofs have been continued in service when burned to a thickness of ¾ in. in the thin spots.

With the use of rib courses the line of thrust is raised with respect to the roof cross-section, so that with the roof burned out, even over a large area, there still remains the full resistance to crushing, up to the strength of the refractory material.

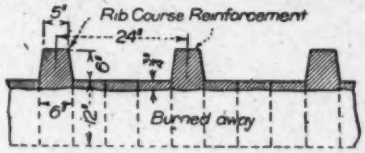


FIG. 2.—CROSS-SECTION SHOWING TYPICAL EXAMPLE OF ROOF BURNING AND APPLICATION OF RIB REINFORCEMENT.

This method of reinforced construction also makes possible a system of repair, when it does become necessary, which, it is said, restores the original strength of the roof more effectively than is possible with ordinary methods of patching. The brick for the rib courses, in the most approved construction, is made with a slight draft, the brick

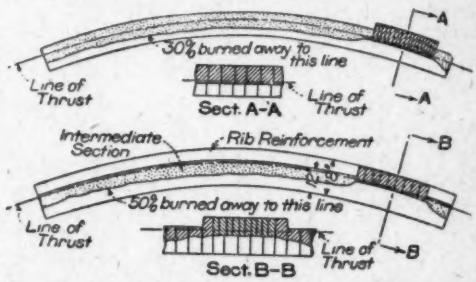


FIG. 3.—FORMER METHOD OF PATCHING A ROOF, WITH LATER METHOD BELOW.

being wider at the bottom. A wedging action is thus set up sufficient to support new roof brick securely when laid in over any area between two ribs. This repairing may be done over much larger areas at one time than is possible where in the common roof the strains set up by the expansion of any considerable area of new brick would wreck

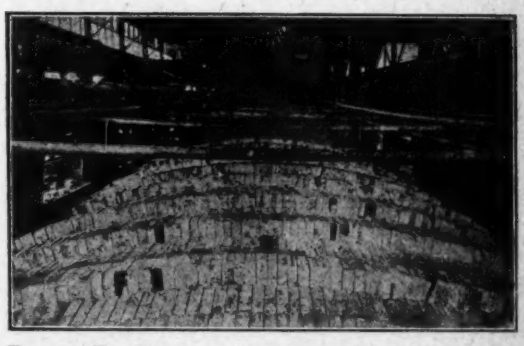


FIG. 4.—TOP VIEW OF NEWLY-BUILT FURNACE ROOF WITH RIBBED REINFORCEMENT.

it, for the reason that the ribs not only separate the patched sections into smaller areas, but also take up the thrusts that are set up by the new brick as it becomes hot. It is also unnecessary, as may be readily understood, to cool down the furnaces to the point necessary in the repairing of common roofs, and in this fact alone a large saving is effected.

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Non-Ferrous Notes.

Sweating of Steam Metal.—While steam metal castings should, if possible, be made sound enough to obviate trouble with "sweating" under pressure, that phenomenon does sometimes occur with castings that are otherwise sound. They may in some cases be made tight by melting paraffin wax in the interior and applying steam or air pressure to force it into the pores.

Alloy for Piston Rings.—A good alloy for piston expansion rings requires to be strong, resilient, and have good bearing qualities. The following mixtures are recommended by "The Metal Record":—(A) Copper 79, tin 10, lead 10, phosphorus 1. (B) Copper 86, tin 8, zinc 6. (C) Copper 86, tin 8, lead 2, zinc 4.

Saddlery Hardware Mixtures.—These are usually composed of the cheapest quality of yellow brass scrap or ingot with as much spelter added as it will stand without becoming brittle. A small quantity of aluminium—usually one or two ounces to a hundred pounds of brass—is used to make the metal run freely.

Care in Pouring Brass Castings.—In pouring yellow brass it always is desirable to keep the head full of metal while the mould is filling. The mould should never be allowed to draw air, as this produces oxide in the mould, which adheres to the walls of the mould, resulting in defects in the casting. A full head of metal prevents the oxide of zinc which forms on the surface from entering the mould.

Sal-Ammoniac.—This is the popular name for ammonium chloride (NH_4Cl). It is a by-product of the manufacture of illuminating gas, obtained by treating with lime a liquid produced in gas-making; ammonia is given off and is passed into hydrochloric acid, thus forming a solution of ammonium chloride, which is then evaporated to crystallisation. Sal-ammonia is used as a flux for alloys containing zinc as a base.

Gun-metal.—While it is quite possible to obtain good gun-metal castings without zinc (as, for example, to the old 90-10 formula), it is very difficult and not necessary for the purposes to which gun-metal is applied. The addition of 2 per cent. of zinc to give the customary 88-10-2 mixture is the result of experience, as it has been proved to produce a cleaner alloy, the zinc being used primarily for its deoxidising influence. The zinc also has a modifying effect on the alloy, and though largely lost to the final metal through oxidation, it gives a toughness which the copper-tin alloy does not have without it. The 90 Cu. 10 Sn. alloy is generally only used with the addition of 0.25 of phosphorus.

Copper Plating Plaster Moulds.—To copper plate plaster moulds the moulds should be first thoroughly dried for a few days in a drying oven, then while warm immersed in molten wax. After removing from the wax they should be wiped quickly with a rag to remove any excess of wax, and graphite powder brushed on with fine brushes, the hooks and wires from the rear of the articles connected and the article placed in the regular electro-plating tank.

Coating with Aluminium.—According to an American patent (No. 1,154,651) a method of coating receptacles with aluminium for the storage and transport of liquids, foodstuffs, etc., involves first heating the surface of the vessel and then giving it a soaking of paraffin, which fills the pores. Aluminium is then sprayed on the surface to a thickness of about 1/10 mm., and penetrates into the finest pores of the article, eliminating all traces of air and moisture. Wood tanks thus treated are found cheaper than those lined with pitch.

Phosphorus in Leaded Bronze.—Much phosphorus should not be used in bronze (copper-tin) containing much lead, as lead and phosphorus do not harmonise, and lead sweating is likely to result. Lead settling and sweating are due to free lead in the mixture, difference in specific gravity and freezing points, and the closing in of the metal by contraction. Any element militating against the dissolution of lead in a lead-tin-copper mixture or closing the grain of the alloy favours respectively lead settling and lead sweating. Phosphorus tends to produce both these results. The highest lead content it is practicable to introduce in a copper-tin bronze is 15 per cent., with tin 7 per cent.

Zinc Losses in Brass Melting.—With zinc at its present price level the question of loss in making and casting brass assumes an important aspect. In this connection it is interesting to recall a process which was the subject of an American patent in 1909, suggested as a means of preventing the customary loss. Instead of melting the copper and then adding the zinc, the zinc is melted first and the copper allowed to dissolve in it. The zinc is covered with a suitable flux such as charcoal or borax, and the copper added in the form of shot, or other small form, and the whole allowed to remain until the brass has been formed. It was claimed that as ordinary brass melts at about 970deg. C., and zinc at 412deg. C., the copper begins to dissolve and forms brass even at the low melting point of zinc, and even though the zinc be raised to the melting point of the brass, which is less than the boiling point of the zinc, the brass is formed without volatilising the zinc itself. Absolute control of the temperature would appear essential, and the process does not appear to have been adopted to any extent.

Burning of Copper.—When it is necessary, for the purpose of making alloys, to melt copper alone, exceptional care is necessary to avoid unduly oxidising it. The oxide which is formed when copper is burned is readily absorbed by the metal itself and the surface is exposed to further oxidation. The addition of charcoal or common salt assists in preventing the trouble, but where scrap metal has to be used in making brass additional protection is obtained by melting some of the scrap first with the copper, as the zinc present in the scrap acts as a deoxidiser and forms a film of zinc oxide on the molten surface which serves to protect it. Some brass rolling mills put a handful of salt in with the copper and some scrap on the bottom of the crucible, and then add charcoal to the crucible to cover the metal at the bottom before melting begins. When the copper begins to melt more charcoal is added to keep the molten metal constantly covered, and then another handful of salt. When the copper has melted the rest of the scrap is added, and well covered with the charcoal. At the right heat the spelter is added, and then the tin and lead; and directly the pouring heat is attained the pot is removed from the fire and the metal poured into the moulds. To leave the metal in the fire after it has melted is to injure it.

Burning-on of Castings.—Discussing the work of the Foundry Inspector, Mr. R. R. Clarke, in "The Metal Record," states that a surface defect on an expensive casting can be often remedied by a "burn-on" and the casting saved. Ordinarily the process consists in embedding the casting in sand, boxing and exposing the vicinity of the defect, and pouring over it hot metal of like composition. At heart the practice is not a good one, and "burn-ons" should be permitted only with the knowledge and consent of the inspector, who will do well to consider:—(1) Was the vicinity of defect well cleaned prior to the burning? (2) Does the vicinity of burn overlap sufficiently the vicinity of defect? (3) Does the burn penetrate the depth of the defect and reach any or all others of probable connection with it? (4) Are any cores or openings in the casting not properly protected into which the metal of the burn might extend? (5) Underneath the burn are there any casting webs or particular parts liable to impairment from the burn? (6) Was the casting warm or cold when the burn was made? (7) Did the head metal of the burn cool placidly or did it kick and spit to the last? (8) Was this head metal chipped away when in cold and solid state, and did it give every evidence of solid attachment in the chipping? (9) Following chipping or buffing, are prominent union lines between burn-on and casting reasonably absent?

Chloride of Zinc in Melting Aluminium.—The use of chloride of zinc as a flux in melting aluminium is claimed by some founders to be very satisfactory in producing sound and clean aluminium castings. Aluminium oxide does not float to the top of the metal, but becomes entangled in the melted metal and results in a semi-pasty mass which even repeated skimming will fail to remove completely. The addition of chloride of zinc helps to remove the oxide and clear the surface on the aluminium. Chloride of zinc is made by dissolving metallic zinc in muriatic acid and evaporating to dryness. It can, however, be purchased quite cheaply. It occurs in commerce in grey lumps which become liquid upon exposure to the air. It must accordingly be kept in tight packages. When used as a flux in melting aluminium, it is thrown on the surface of the melted metal, the quantity depending upon the amount of dross on the surface of the metal. For example, a small piece about the size of a walnut thrown on the surface and stirred in causes a violent reaction accompanied by some smoke, and when this has ceased, the surface of the aluminium is quite clear, if sufficient chloride of zinc has been used; otherwise more must be added. The oxide changes to a light powder, which is easily skimmed off.

Practical Substitutes for Platinum and its Alloys.—A paper on this subject, contributed to the "Transactions of the American Institute of Mining Engineers," states that experimental work conducted in the endeavour to find practical substitutes for platinum and its alloys resolved itself into three parts, each being marked by a different method of attack, necessitated by limitations encountered as the work progressed under previously adopted methods. The first part consisted of experiments on binary combinations of those of the metals which it was feasible to consider, and the melting points of which lay within the limits of ordinary fusion methods. The results of these experiments lead to the conclusion that metals or alloys of metals outside of the precious-metal groups are unsuitable as substitutes for platinum. The gold and silver alloys of palladium were found to be excellent substitutes for platinum in its softer forms, and while not so chemically resistant, fill all requirements where conditions are not too rigid. The second part revealed the fact that except in two respects, pure ductile tungsten, and, to a lesser degree, molybdenum, meet all of the specifications of a practical substitute for platinum and its alloys. These two defects are its ease of oxidation, and the difficulty with which it can be soldered; and they have been overcome by coating with a precious metal or alloy, the resulting material being in many ways far superior to platinum or its alloys. This material has met with instant demand, is in many cases replacing the best platinum-iridium alloys, and permits the performance of work which has been impossible with the materials hitherto available. The third part related to the theoretical and practical considerations involved in the manufacture of wrought tungsten and molybdenum, and gave results of the proper application of a similar method in the laboratory production of their alloys. Wrought tungsten and molybdenum were produced on a laboratory scale, but no success attended the attempted production of alloys of tungsten with gold and palladium; while on the other hand, the alloys of the tungsten-molybdenum series were produced in wrought form. These operations were governed entirely by metallographic control, and their success suggests the possible application of a similar method in a treatment of such metals as iridium, tantalum, rhodium, osmium, etc., in combination with each other, or with tungsten or molybdenum, which may result in the production of alloys possessing properties far superior to those of any material now available.

Nickel-Plating Aluminium.—In general the deposition of nickel by electrolytic means necessitates a preliminary deposit of some other metal. Copper, zinc and iron have been variously recommended as available for this purpose, but the final nickel coatings obtained have shown anything but the desired degree of adherence. Aluminium thus nickel-plated cannot be worked. However, among recently proposed processes, one patented in France and other countries by J. Canac appears to permit the direct deposition of nickel on aluminium in an adherent form. To cleanse the metal it is passed through a bath of boiling potash; then it is scrubbed with milk of lime; next it is soaked in a bath of 0.2 per cent. of potassium cyanide for several minutes; and then it is subjected to the action of an iron hydrochloric acid consisting of 500 parts of hydrochloric acid, 500 parts of water and one part of iron, until the metal takes on a certain appearance best described as a metallic "watering." After each of these operations it is washed in water. The nickel plating proper presents no features of importance so far as the composition of the electrolyte is concerned. The following formula is satisfactory:—Water, 1,000 c.c.; nickel chloride, 50 grm.; boric acid, 20 grm. For depositing the metal is used a current of 2½ volts, 1 ampere. The piece of metal coming from the bath has a pleasing soft-grey appearance, and easily takes on a metallic lustre when polished with a wire brush. Whether the plating be light or heavy, the deposit is always remarkably adherent. It will endure hammering; in sheet form it can be bent without cracking, and it is only by fracture of the aluminium that the metal is exposed. "Aluminium nickel" can be heated without deformation up to the fusing point of aluminium. It would seem that the peculiar surface which the aluminium has when it issues from the hydrochloric bath gives the nickel an opportunity to deposit itself under conditions especially favourable for rendering it adherent. The result is not at all the same if hydrochloric acid of equal dilution be employed alone. A close examination shows that on the aluminium sheet from the iron-acid bath a light deposit of iron is found. The quantity of iron distributed over the aluminium was found to vary from ¼ to ½ gram per square meter. The significance of the iron deposit as a continuous intermediate layer is thus negligible. On the other hand, an examination of the metal cleaned in the iron-acid bath shows the surface full of minute cavities; in these the nickel proceeds to deposit in the process of electrolysis. It appears that the iron forms a network on the surface of the aluminium and develops a multitude of couples, which assist the hydrochloric acid to attack the aluminium at certain points, action being set up more or less energetic according to its proximity to the iron, which thus acts rather as an excitant. The result is that peculiar aspect of the aluminium surface particularly adapted for anchoring a deposit.

Osmium-Platinum.—Among comparatively recent alloys of platinum was one introduced in America a couple of years ago by F. Zimmermann. The growing scarcity of iridium, employed in the iridium-platinum alloys, led to the search for other combinations of the metals of this group yielding alloys possessing physical and chemical properties of equal if not greater value. The rarer metals of the platinum group are not easily obtained in great purity, and because of this fact but little success had been obtained when combining them as bivalent alloys. Further, the strong affinity of osmium for oxygen increased the difficulty of making alloys of it with other metals in definite proportions. After much experimenting, however, highly refined platinum and osmium were successfully combined in widely varying proportions yielding alloys of commercial value. While the two metals may be combined in almost any proportion, alloys containing from 1 to 10 per cent. of osmium and 99 to 90 per cent. of platinum are chiefly used. Great purity of the components is essential, as the presence of small percentages of other elements appears to be very detrimental to the properties of the resulting alloy. According to the chemical and physical behaviour, it seems that one part of osmium in an alloy with platinum will take the place of two and one-half times its weight of iridium. The osmium-platinum alloy is very acid-resisting, and its electrical resistance is considerably higher than that of an iridium-platinum alloy of the same percentage composition. The alloy further possesses great hardness and tensile strength.

Trade Talk.

THE Swedish Government has decided to prohibit the export of zinc, unmanufactured (except zinc produced from imported raw materials).

THE French Government has issued an order prohibiting the exportation from that country of tungsten, both in metal and ore form.

IN item 38 in the list of absolute contraband the more general term "lead" has been substituted for the words "lead, pig, sheet, or pipe."

MESSRS. H. W. ROBINSON and C. L. LOYD, engineers, 39, Keen's Road, Croydon, trading as the Royle Engineering Company, have dissolved partnership.

FROM July 2, 1915, up to the end of December last, the Cutlers' Company, of Hallamshire, granted no fewer than 35,000 certificates for the export of steel.

AN outbreak of fire has occurred on the premises of Steel Castings, Limited, 253, Old Edinburgh Road, Parkhead, Glasgow. Considerable damage was done to the engine house.

THE shareholders of the Sheffield & Swedish Steel & Iron Company, Limited, have decided that the company be wound up voluntarily, and that Mr. R. P. Glanville be appointed liquidator.

MR. R. H. CLARK, 124, St. Vincent Street, Glasgow, has been elected trustee of the sequestrated estates of the Glasgow Harbour Foundry Company, Moorpark, Renfrew, and J. Wilson and T. Hill the sole partners.

MESSRS. A. E. WHITE, A. S. WHITE, and F. G. WHITE, carrying on business as engineers, boiler makers, and shipbuilders, at the Vectis Works, Cowes, Isle of Wight, under the style of W. White & Sons, have dissolved partnership.

THE Scotch blast furnaces have been put under Government control as from January 1, 1916. The number of furnaces in blast in Scotland at present is 71, of which 50 are engaged in the production of hematite iron and the remainder ordinary iron.

MR. ALFRED HERBERT, Director of Machine Tools, informs us that the offices of the Machine Tool Department of the Ministry of Munitions have been removed from Armament Buildings, Whitehall, S.W., to Queen Anne's Chambers, Dean Farrar Street, Westminster, S.W.

MESSRS. J. BILBIE, J. S. WYLDE, AND H. G. HALE, carrying on business as engineers, at 106, Queen Victoria Street, London, E.C., and Deverell Street, Great Dover Street, S.E., under the style of Bilbie, Hobson & Company, have dissolved partnership, so far as concerns Mr. H. G. Hale.

MR. A. J. GREENLY and Mr. T. Denison have taken over Messrs. Baldwin & Wills' works, St. Albans Road, Watford, and have commenced business as manufacturing electrical and mechanical engineers under the style of Greenly & Denison. The offices of the partnership are at 37 and 38, Strand, W.C.

THE partnership heretofore subsisting between Messrs. John Henry Horsfall and Sam Horsfall, carrying on business as ironfounders, at Square Road, Halifax, Yorks, as William Horsfall & Sons, has been dissolved. All debts due to and owing by the firm will be received and paid by Mr. John Henry Horsfall.

THE partnership heretofore subsisting between Messrs. G. Bourne, W. Hitchman, G. F. Bourne, and F. W. Hitchman, carrying on business as brassfounders at Weaman Street, Birmingham, under the style of Joseph Steer has been dissolved. Messrs. G. Bourne, G. F. Bourne, and F. W. Hitchman will continue the business under the same style.

THE BOARD OF TRADE, in order that British manufacturers may have an opportunity of familiarising themselves with German methods of publicity, have collected over 3,000 specimen catalogues of German origin, illustrating a great variety of industries, and these may be inspected at the Foreign Samples Section of the Commercial Intelligence Branch, 32, Cheapside, E.C.

IT has been resolved by the members of the Pensnett Foundry & Tinning Works, Limited, in order to reconstruct the company, that it be wound up voluntarily, and that Mr. A. E. Mason, of Wolverhampton Street, Dudley, be appointed liquidator. A draft agreement between the company and its liquidators of the one part, and Metalclad, Limited, of the other part, has been approved.

THE MINISTER OF MUNITIONS announces that he has made an order under Section 4 of the Munitions of War Act, 1915, declaring 298 additional establishments as controlled establishments under the Act, as from January 31, 1916. A total of 2,720 establishments have now been declared as controlled under the Act from the date of the first order, July 12, 1915, to January 31, 1916, inclusive.

A NEW canteen for female workers has been opened at the Paisley works of Wm. Beardmore & Company, Limited, by Sir William Beardmore. He announced that as an inducement to girls in the Paisley factory, a bonus of 10 per cent. on the total wages earned by female workers would be paid by the firm as from January 1 of this year till the termination of the war, on condition that the girls kept regular time, gave satisfaction to the management, and when absent owing to illness gave a satisfactory explanation.

MR. EDGAR J. WINDSOR RICHARDS, the late general manager of the Glengarnock Iron & Steel Company, Limited, who retired early last year on account of that company closing their works, has opened offices at 90, Mitchell Street, Glasgow, as consulting and inspecting engineer. Mr. Richards has had thirty-five years' experience with Messrs. Bolckow, Vaughan & Company, the Barrow Hematite Steel Company, and also in the United States with the Carnegie Company, and the Lackawanna Steel Company. During his term of office at Glengarnock he practically rebuilt the entire works, on the most up-to-date principles.

INFORMATION regarding the new company formed in Canada under the title of the Canada Iron Foundries, Limited, under the scheme of reorganisation of the Canada Iron Corporation, Limited, has been issued to holders of the 6 per cent. first mortgage bonds of the latter undertaking. The scheme provides for the exchange of bonds for an equal nominal amount of 6 per cent. "B" debenture stock in the new company, plus 10 per cent. of that amount in fully-paid ordinary shares. The new company has an authorised capital of £900,000, in £500,000 6 per cent. non-cumulative preference shares and £400,000 ordinary shares. Debenture stocks have been created, comprising £200,000 6 per cent. "A" debentures.

THE BOARD OF TRADE (EXHIBITIONS BRANCH) has issued a notice calling attention to certain provisions of the Defence of the Realm Act empowering the Minister of Munitions to prohibit, or impose restrictions on the holding of industrial exhibitions and fairs during the war, in order to prevent the production of war material being prejudicially affected. In consequence, the forthcoming British Industries Fair will be confined to exhibits not likely to interfere with the output of munitions. It is stipulated that any firm who hold contracts for a Government Department will have to obtain the permission of the Department before exhibiting. Similar restrictions will be imposed on the holders of any other industrial exhibitions and fairs.

THE BOARD OF TRADE has issued a warning to importers that they are under an obligation to take all necessary steps to satisfy themselves that goods they propose to import are not of enemy origin. Failing evidence that they have done so, the goods, should they prove, as a result of examination on arrival, to be of enemy origin, will be liable to seizure, even though accompanied by Consular certificates of origin. Importers who are offered goods (especially goods hitherto mainly derived from enemy countries) by firms abroad respecting which they have insufficient information, are strongly advised to defer payment until the goods are delivered, and to make it a condition of payment that the goods are not only accompanied by certificates of origin in proper form, but are passed on arrival by the Customs authorities of the United Kingdom.

THE MINISTER OF MUNITIONS has issued a notice that all persons who desire to import from France, Italy, or Russia materials required in connection with the manufacture of munitions of war, being materials of which the export from the country in question is pro-

hibited or restricted, should submit their applications to the Director-General of Munitions Supply, B.M.3, Armament Buildings, Whitehall Place, S.W. The application must contain :—(*a*) A precise description of the nature and quantity of the goods which it is desired to import; (*b*) a statement of the use to which they are to be put, and any evidence, such as references to direct or indirect Government contracts, tending to show that they are required for the manufacture of munitions of war; (*c*) the name of the firm or firms to whom they are to be consigned, as well as that of the firm or firms on whose behalf they are purchased. The Minister of Munitions will then, in approved cases, take all the necessary steps with a view to obtaining from the Government concerned a licence to export the goods in question.

GLUTRIN, the core-binding material, is the subject of a couple of booklets, forwarded by Mr. Wm. Olsen, of Hull, in which it is explained that glutrin is a nimble liquid which quickly works into the spaces between the grains of sand; it is not an oil, but its action is similar to that of oil, in that when baking it is drawn to the contact points of the sand, leaving the spaces between the grains of sand clean and open, producing a porous core, the advantage of which needs no explanation. Glutrin cores are said to be exceptionally strong when green, but, as the binder is an air dryer, the cores made with it retain their shape until placed in the oven; and when they are in the oven they do not swell or otherwise change in size. The binder does not melt under the heat of the oven and work down to the bottom of the core, causing the core to be too strong in one part and too weak in another. It does not smoke in the mould, nor in the oven while baking; also it does not ferment, and is proof against changes in temperature, and as it contains no acid it does not injure the hands, nor the core boxes. The castings with such cores are easily cleaned, which is illustrated by the statement that one foundry has cast rolls 6 ft. long and 6 in. in diameter, with a one-inch hole in the end through which the cores cleaned out perfectly.

THE high-speed steel manufacturers of Sheffield have accepted the prices and conditions laid down by the Government for the sale of high-speed steel. The meeting at the Cutlers' Hall, which was fully representative of the High-Speed Steel Association, was presided over by Mr. P. Macgregor, who, at the close, was warmly thanked for his conduct of the negotiations on behalf of the makers. The following are the prices and conditions which, it was explained, must be strictly observed in all transactions connected with the sale of high-speed steel :—Ordinary quality, approximately 14 per cent. tungsten, 2s. 10d. per lb. (basis); superior quality, approximately 18 per cent. tungsten, 3s. 10d. per lb. (basis), nett cash, delivered at the customers' works, with the following extras :—Rounds and squares, 3 in. to 8 in. inclusive, 4d. per lb; ditto, under ½ in. to ¼ in., 3d. per lb.; flats, under 1 in. by ⅜ in. to ½ in. by ¼ in., and of sizes over four times in width over thickness, 3d. per lb.; bevels of approved sizes and sections, 6d. per lb.; bars cut to length, 10 per cent. extra; exceptional sizes and sections not covered in the above list subject to special quotation; oddment orders of less than 56 lbs., of a size, 3d. per lb. extra. The above list of extras has been compiled to represent as nearly as possible the average practice of the trade. The prices quoted relate to the home trade only.

A BRITISH mission was recently appointed to visit the industrial districts in France and to report on the causes which have contributed to the enormous increase which has taken place in the production of munitions in that country. The mission consisted of Messrs. J. T. Brownlie, chairman of the Amalgamated Society of Engineers; F. Duckham, Ministry of Munitions; D. J. Shackleton, Labour Advisor, Ministry of Munitions; and A. M. Smith, secretary of the Engineering Employers' Federation, together with two engineering experts. The report contains much information of a valuable nature, and also observations and conclusions on the position generally. The general conclusions at which the mission have arrived are :—(*a*) The people of France realise that they are at war; (*b*) the one idea in the mind of all is to bring the war to a successful issue; (*c*) the spirit which dominates the nation has prevented difficulties arising in the manufacture of war material; (*d*) loss of time is practically negligible; (*e*) no Trade Union restrictions exist at the moment; (*f*) everything is done to increase production; (*g*) no limitation of profits exists, and no question in this respect has been raised by the workpeople; (*h*) the manner in which the employers in France have been able to acquire machinery and the initiative and energy displayed by them are beyond all praise; (*i*) in conclusion, it appears to the mission that the increase of production in France is due to one cause, and one only, and that is the patriotic enthusiasm which exists there.

AFTER an exhaustive study of English, American, and Continental systems, the Monometer Manufacturing Company, Limited, Whitehouse Street, Aston, Birmingham, have placed on the market their latest design of tilting furnace, which embodies, not only the good points of other furnaces, but many patented improvements of their own. Recent orders for these furnaces include ten each of 600 lbs. capacity, and seven of the same size for melting Delta metal swarf, the latter furnaces having turntables to carry a series of moulds. Repeat orders have also been taken for the company's aluminium furnace, which comprises a system of melting without oxidation and without crucibles. Soft metal furnaces for tin, lead, etc., are also being freely ordered, particularly for export. In hardening furnaces numerous orders have been received, the company's being the only muffle on the market with automatic heat control, consequently ensuring accurate temperature. Other orders include a 10-cwt. white-metal furnace, specially arranged to line white-metal bearings, as well as shell-drying ovens, and the company's patented self-acting heat controller. Complete batteries of the tilting furnaces have been ordered for new arsenals, while other contracts have been placed by Hunter, Wigham Richardson, Limited, Foster & Company, Daimler Motors, Limited, Chance Brothers, Mr. E. Williams, Sheffield Corporation, Adam Hilgers, Limited, Davies & Metcalfe, Hack Saws, Limited, the John Dale Manufacturing Company, the Lead Wool Company, Mr. J. Branfield, Claridge & Company, Harper Brothers, Waltham Ironworks, Limited, Crompton & Company, Limited, Joseph Lucas, Limited, and many others.

PROBABLY never before in the history of the Cleveland Institution of Engineers at Middlesbrough has there been so large an attendance as that which assembled to hear Dr. Stead's Paper on "German Shells." Apart from the interest of the Paper, which attracted a large gathering of the members of the Institution, there was also a considerable muster of skilled workmen present, at Dr. Stead's express invitation. This was the sequel to a rather vigorous correspondence in the "North-Eastern Daily Gazette," in which Dr. Stead had severely rallied local munition workers upon their failure to produce the maximum output. There were many angry replies, in which Dr. Stead was accused of "going for" the men to the exclusion of employers and other offenders. Hence the invitation to hear the lecture, with a view to convincing the men that Dr. Stead was out for efficiency all round. At the conclusion of his Paper, Dr. Stead appealed to workmen, to get out of rules which bound them to degrade the working capacity of the best workman to that of the inferior. At the same time, he was one with the workmen in denouncing big war profits. His advice to workmen was to do their best, and not to think of what would happen after the war. Let them demand that the best workmen should have the best pay, and let them strike if employers did not use improved plant which would enable them to produce as cheaply as competitive nations. In this connection he quoted the statement that the average American workman produced three times as much as a British workman, but they used nearly three times as much horse-power in machinery. He had long felt that Labour was not properly represented on the boards of directors of industrial undertakings. He suggested that workmen who had been four or five years in their employment should be allowed to elect one of their number on the board, and this, he thought, would tend to greater harmony and co-operation.

Deaths.

MR. H. MYER, of H. Myer & Company, Limited, Surrey Ironworks, 83, Vauxhall Walk, Lambeth, S.E., has died at the age of 66 years.

MR. W. MCLAREN, chairman of G. D. Peters & Company, Limited, and the Superheater Corporation, Limited, has died at his residence, Blackdown, Woking, Surrey, at the age of 62 years.

CAPT. AND ADJT. JAMES LUSH, 6th Batt. the Cameronians (Scottish Rifles) (T.F.), who has died from wounds received in France, was a director of David Colville & Sons, Limited, Dalzell Steel & Iron Works, Motherwell.

THE death has occurred at Newcastle of Mr. Stephen Lawson, who for many years has occupied the position of director of ordnance at the Elswick Works of Sir W. G. Armstrong, Whitworth & Company, Limited. Mr. Lawson, who was 73 years old, has been employed by the firm for over 59 years.

MR. GRAHAM FRASER, one of the founders of the iron industry in Nova Scotia, died recently at New Glasgow, N.S. The deceased established the Hope Iron Works, which subsequently developed into the Nova Scotia Steel & Coal Company. At one time he was a director of the Dominion Iron & Steel Company, Limited.

THE death of Mr. Henry Wick, of Youngstown, U.S.A., has removed one of the most prominent figures in the establishment of the Mahoning and Shenango valleys as a steel-producing centre. Previous to the construction of the works of the Ohio Steel Company, at Youngstown, the valleys had been purely an iron-producing locality.

THE death has taken place at Philadelphia, U.S.A., at the age of 72 years, of Mr. C. C. Schneider, one of the most prominent of American bridge engineers. During the many years he was consulting engineer and chief engineer to the American Bridge Company, the deceased gentleman was instrumental in instituting rational engineering design in bridge construction.

INFORMATION has been received in Belfast of the death from wounds of Lieut. E. Workman, Royal Irish Rifles. Lieut. Workman, who was 29 years of age, was a son of Mr. Frank Workman, founder of the well-known shipbuilding and engineering firm of Workman, Clark & Company, Limited. He was educated at Cambridge, and subsequently entered his father's firm, in which he held a directorate at the outbreak of the war.

THE death is announced of Mr. Andrew Kirkwood M'Cosh, one of the most prominent of Scottish iron-masters. For many years he was resident at Cairnhill House, Airdrie, in close proximity to the Coatbridge and Gartsherrie Ironworks of Messrs. William Baird & Company, Limited, of which he was managing director, and with which business he was associated all his life. Mr. M'Cosh was a native of Ayrshire, and went to the Gartsherrie Works as a young man, rising step by step to positions of responsibility and trust until he became managing director of the undertaking.

SIR FRANCIS LEY, Bart., died recently at his residence, The Manor House, Epperstone, Notts, at the age of 70 years. Born at Burton-on-Trent, he was the only son of Mr. George Ley. He built up a successful business at Derby in the manufacture of malleable castings, which is now carried on as Ley's Malleable Castings Company, Limited, of which the deceased was governing director. He received his baronetcy in 1905, and was a Justice of the Peace for Notts and Derbyshire, and had been High Sheriff of Notts. He was Lord of the Manors of Epperstone and of Lazonby and Kirkoswald, Cumberland.

THE death is reported of Mr. Lewis Grant, J.P., chairman of the firm of Douglas & Grant, Limited, Dunnikier Foundry, Kirkcaldy. Mr. Grant was born 72 years ago at the Manse at Cavers, Roxburghshire. On the death of his father the family removed to Edinburgh, where he was educated. He entered the engineering profession, and on completing his apprenticeship sailed for some time as a marine engineer. While yet a young man he was appointed manager of an engineering works, and afterwards went to Kirkcaldy where he joined with the late Mr. Douglas in forming the firm of Douglas & Grant.

THE death has taken place at "Llysbrechfa," Caerleon, Mon., of Mr. Edwin Richards, J.P., of "Heathfield," Nantyderry, in his 87th year. The deceased gentleman, who was a brother of Mr. E. Windsor Richards, J.P., was born at Dowlais 87 years ago. Until a few years ago he was intimately associated with the iron trade of Wales, being connected with the Tredegar Iron & Coal Company, Limited, the Rhymney Iron Company, Limited, and the Ebbw Vale Steel, Iron & Coal Company, Limited. He was one of the original members of the Iron and Steel Institute.

MR. F. H. LLOYD, J.P., Stowe Hill, Lichfield, whose death is announced, was born in 1884, and was the son of the late Mr. Sampson Lloyd, J.P., of the firm of Lloyd, Foster & Co., now the Patent Shaft and Axletree Company (Limited). After leaving college Mr. F. H. Lloyd took an active part in the control of that firm, having charge of the Bessemer steel department. He continued the head of the department under the Patent Shaft & Axletree Company, Limited, to whom the business was transferred in 1867. Mr. Lloyd severed his connection with the company in 1874. For some years he was connected with the extensive works of the Darlaston Steel and Iron Company, Limited, and afterwards built the steel foundry at James Bridge, of which he was the sole proprietor. In 1888 the business was transferred to a private company, of which he was chairman. Since that time the business has grown to large proportions.

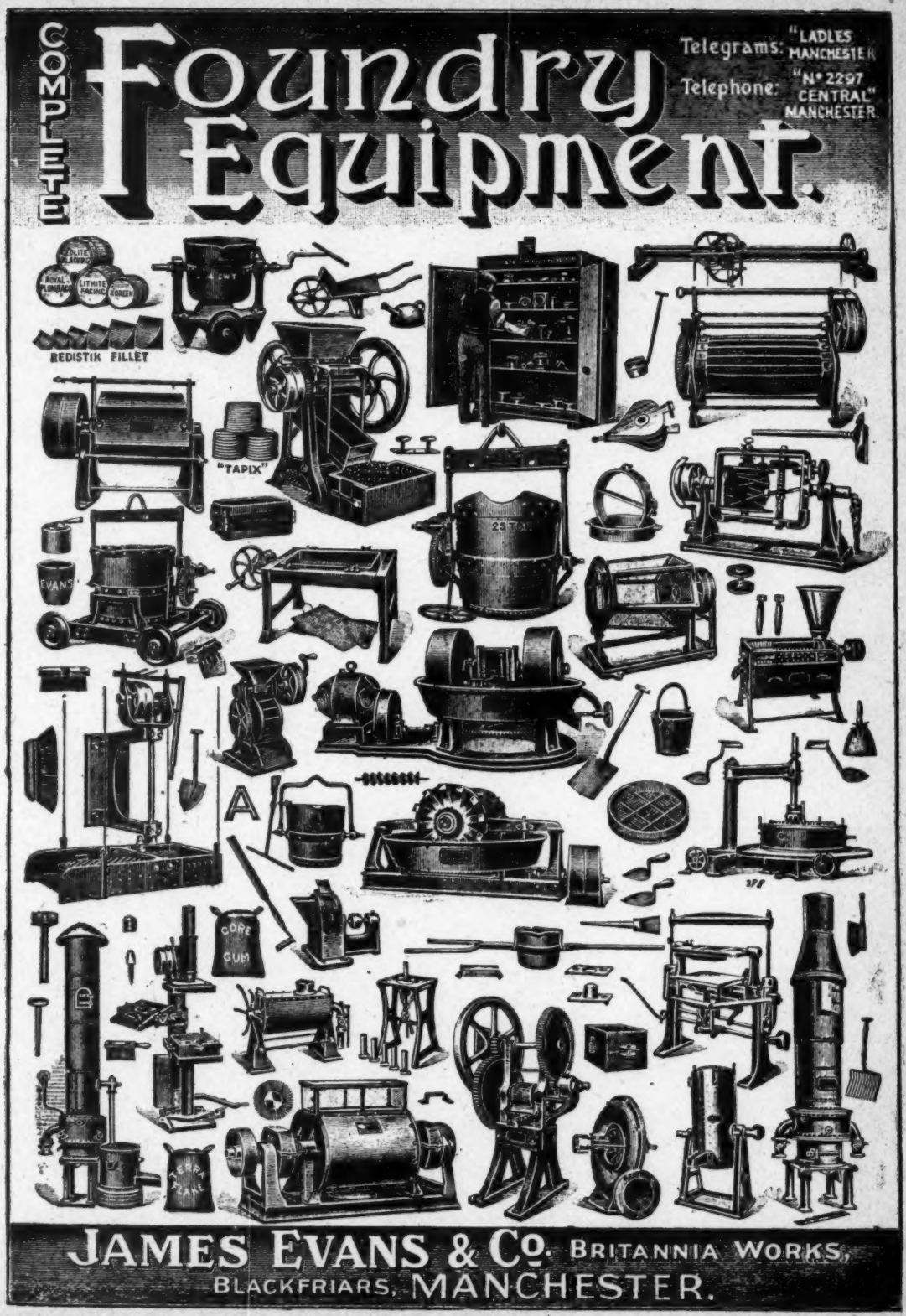
MR. WILLIAM THOMAS BEESLEY, has died at his residence Whitton Park, Middlesex. Mr. Beesley, who was 77 years of age, commenced his business career at the works of Messrs. Samuel Fox & Company, but many years ago he set up in business for himself, with his two sons, at the Universal Steel Works, Wire and Rolling Mills, Attercliffe Road, Sheffield. In the eighties Mr. Beesley formed his business into a private limited company, under the style of W. T Beesley & Company, Limited, and this concern and that of Messrs. Colver Brothers, Limited, became amalgamated with Sir Joseph Jonas, Colver, & Company, Limited, then Jonas and Colver, Limited. Mr. Beesley became a permanent director of all three companies and managing director of the Beesley Company, and so remained until failing health a few years ago caused him to resign these permanent directorships in favour of his son, Mr. Herbert Beesley, of Belmont, Sheffield.

Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

17,651. Producing cores for and casting "stick" and like bombs and substantially spherical bodies and hollow-ware generally. J. N. Chadwick.
17,902. Crucible furnaces. J. Keith and G. Keith.
17,911. Tyre-moulding machines. J. H. Coffey and J. H. Coffey, Jun.*
17,967. Apparatus for cutting steel bars. A. Pécard-Chauvean.
17,971. Furnaces. I. Hall.
17,978. Recovery of metals from ores. H. Dixon.
18,064. Machines for cutting off pieces from bars. C. Taylor, Limited, and G. B. Taylor.
18,072. Firing gas furnaces. J. Keith and G. Keith.
18,090. Manufacture of steel. C. H. F. Bagley.
18,115.* Alloy for arc welding. D. H. Wilson and S. M. Rodgers.

THE partnership heretofore subsisting between Messrs. G. W. Hallatt and F. Ashmore, carrying on business as brass, etc., casters, at 1, Court Leadmill Road, Shoreham Street, Sheffield, under the style of Hallatt & Ashmore, has been dissolved. Mr. Ashmore continues the business


COMPLETE
Foundry Equipment.
Telegrams: "LADLES MANCHESTER"
Telephone: "No 2297 CENTRAL" MANCHESTER.
REDISTIK FILLET
"TAPIX"
EVANS
CORE GUM
JAMES EVANS & Co. BRITANNIA WORKS,
BLACKFRIARS, MANCHESTER.

Personal Notes.

Mr. M. R. Mainprice and Mr. Harry Brearley have been elected directors of Brown, Bayley's Steel Works, Limited.

The late Mr. George Senior, J.P., chairman of George Senior & Sons, Limited, left estate valued at £76,430 gross.

The gross value of the estate of the late Mr. H. A. Allport, a director of the Holwell Iron Company, Limited, is £56,313.

Mr. A. M. Duckham, of the Munitions Inventions Department, has been appointed Deputy Director-General of Munitions Supply.

The late Mr. J. J. Robinson, of Joseph Robinson & Company, Springfield Ironworks, Birkdale, Lancs., left estate valued at £317,199 gross, with net personalty £290,152.

Mr. James Currie has been appointed to give effect to the policy of the Labour Supply Department of the Ministry of Munitions in relation to the training of munition workers.

The Minister of Munitions, it is announced, has appointed Mr. Seebohm Rowntree to assist Lord Murray on problems arising out of the employment of women as munition workers.

The Right Hon. Joseph A. Pease, M.P. for the Rotherham division of Yorkshire since 1910, who has been appointed Postmaster-General, is a director of Pease & Partners, Limited.

Mr. A. G. Ingleby, late of the Adnil Electric Company, has been appointed to take control of the engineering department of the Electrical Supplies Company, 233, Tottenham Court Road, London, W.

The late Sir Andrew Noble, Bart., chairman of Sir W. G. Armstrong, Whitworth & Company, Limited, Elswick, and the Bede Metal & Chemical Company, Limited, and a director of the Mond Nickel Company, Limited, left estate valued at £734,418.

Probate has been granted by the will of Mr. J. E. Maddock ironfounder, of Eastfield, Roslyn Road, Wellington, Salop, who died on October 19 last. Deceased left estate of the gross value of £8,348 4s. 4d., of which £7,984 18s. 2d. is net personalty.

Sir Philip Watts, K.C.B., has been elected a director of Sir W. G. Armstrong, Whitworth & Company, Limited. During the course of his career Sir Philip Watts has been naval architect to the firm, Director of Naval Construction at the Admiralty, and adviser in naval construction at the Admiralty.

The Duke of Devonshire, who has been appointed Knight of the Order of the Garter, in the New Year Honours, is chairman of the Barrow Hematite Steel Company, Limited, and a past-president of the Iron and Steel Institute. A barony of the United Kingdom has been conferred upon Admiral Lord Charles Beresford, M.P., chairman of John Henry Andrew & Company, Limited, Toledo Steel Works, Sheffield. The new Baronets include Sir George Bullough, a director of Howard and Bullough, Limited; Mr. A. F. Yarrow, head of the well-known firm of shipbuilders and engineers, Yarrow & Company, Limited. Mr. George Franklin, a director of the British Thomson-Houston Company, Limited, has received a Knighthood.

The following members of Council of the Institution of Mechanical Engineers are retiring at the forthcoming annual meeting:—President: Dr. W. C. Unwin; Vice-Presidents: Mr. Henry Davey and Mr. Michael Longridge; Members of Council: Dr. A. Barr, Dr. H. S. Hele-Shaw, Mr. Alfred Herbert, Mr. Walter Pitt, Mr. V. L. Raven, Captain H. Riall Sankey, and Mr. Wilson Worsdell. All, with the exception of Mr. Herbert, have offered themselves for re-election. Mr. Bowman Malcolm, of Belfast, Mr. William Reavell, of Ipswich, and Mr. David Evan Roberts, of Cardiff, will be included in the ballot. It has been decided to alter the articles of association so as to be able to adequately deal with such difficulties as the renewal of the subscriptions of members on active service, and also those members who have been seriously affected financially by the conditions of the times.

Welfare Supervision.*

The Health of Munition Workers' Committee, whose duties are "to consider and advise on questions of industrial fatigue, hours of labour, and other matters affecting the personal health and physical efficiency of workers in munitions factories and workshops," have issued a Memorandum on the subject of "Welfare Supervision"—a subject which is now receiving the attention of the more enlightened employers.

The Committee desire to record their unanimous conviction that a suitable system of Welfare Supervision (to be administered by an officer specially appointed for the purpose) is essential in munition works where women or girls are employed, and, they must add, urgently necessary. The officer appointed should be a woman of good standing and education, of experience and sympathy, tactful and sensible in her dealings with others, and having, if not an actual experience, at least a good understanding, of industrial conditions. She should live near the factory and keep in close touch with all the women and girls employed. In general the duties of Welfare Supervision should include the following:—

(1) To be in close touch with the engagement of new labour, or, when desired, to engage the labour.

(2) To keep a register of available houses and lodgings; to inform the management when housing accommodation is inadequate; and to render assistance to workers seeking accommodation.

(3) To ascertain the means of transit used, and the length of time spent in travelling; to indicate the need of increased train, tram, or motor service, or to suggest modification of factory hours to suit existing means of transit.

(4) To advise and assist workers in regard to feeding arrangements; to investigate the need for provision of canteen facilities or any inadequacy in the provision already made; and to supervise the management of such canteens.

(5) To investigate records of sickness and broken time arising therefrom; and in cases of sickness to visit, where desired, the homes of workers.

(6) To investigate, and advise in, cases of slow and inefficient work, or incapacity, arising from conditions of health, fatigue, or physical strain.

(7) To consider, particularly for delicate and young workers, all questions of sanitation and hygiene affecting health and physical efficiency, and to supervise the conditions of night work, Sunday work, long hours, and overtime.

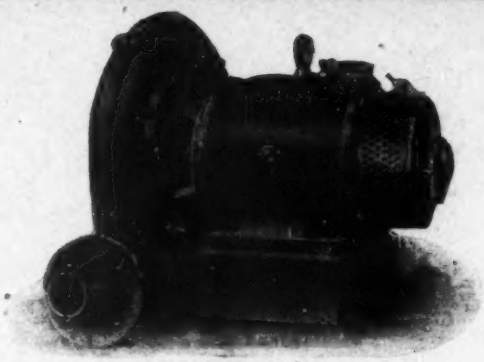
(8) To advise on means of recreation and educational work.

(9) To investigate complaints and assist in the maintenance of proper discipline and good order.

(10) To keep in touch with responsible organisations having for their object the promotion of the welfare of the worker.

When it is impracticable to appoint a whole-time woman supervisor, the duties of welfare supervisor should be allotted to a woman on the factory staff specially designated for the purpose. As regards men and boys, the Committee consider that a suitable system of Welfare Supervision (to be administered either by the ordinary factory staff or by an officer specially appointed for the purpose) would be of advantage in munition works where 500 adult males or 100 boys are employed. Where numbers greatly in excess of 500 men or 100 boys are employed, additional welfare supervising staff may become necessary.

* "The Labour Gazette."



10 H.P. Fan and Motor.

TRADE SIROCCO MARK

High Pressure Fans

Are made in a large number of sizes from 10 in. diameter upwards.

Bulletins 2000 F. and 2028 F.

Some Points worth noting.

Owing to few wearing parts, the Fans are not liable to break down. The mechanical efficiency is high and remains so. The pressure is steady and the volume even and free from pulsations.

Davidson & Co., Ltd.,

Sirocco Works,
BELFAST.

ELDER'S FOUNDRY COKE

AS SUPPLIED TO THE
BRITISH
ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1901.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glosgow.

Paisley, 12th March, 1909

Oe have yours of 4th inst., and ic reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Celtic Colleries, Ltd., Cardiff.

Telegraph: "OUTPUT, CARDIFF." Telephone: 4740 & 4641.

New Companies.

Edward Simpson & Company, Limited.—Capital £15,000 in £1 shares, to carry on the business of engineers and tool manufacturers.

T. E. Bladon & Company.—Capital £5,000, to carry on the business of brassfounders, tinsmiths, lamp makers, oil-can manufacturers, etc.

H. E. Jackson.—Capital £2,500 in £1 shares, to carry on the business of ironfounders, mechanical and electrical engineers, electricians, etc.

Valves, Limited.—Capital £1,000 in £1 shares, to carry on the business of general engineers, etc. F. E. Bullock is permanent managing director.

John Frew & Company, Limited.—Capital, £4,000 in £1 shares, to acquire the business of John Frew & Company, Hamilton Foundry, Hamilton.

Anglite, Limited.—Capital £5,000 in 4,500 preferred ordinary shares of £1 each and 10,000 deferred shares of 1s. each, to carry on the business of engineers.

J. M. Dartois & Company, Limited.—Capital £10,000, in 800 "A" shares of £10 each and 40,000 "B" shares of 1s. each, to carry on the business of iron merchants.

Dawson & Downie, Limited.—Capital, £25,000, in £1 shares, to carry on the business of engineers, brass and iron founders, etc. Registered offices :—Elgin Works, Clydebank.

Metalclad, Limited.—Capital, £2,000, in £1 shares, to take over the business of founders and tinners carried on by the Pensnett Foundry & Tinning Works, Limited, at Corbyn's Hall, Stafford.

S. Bullock & Company (London), Limited.—Capital £12,000 in £1 shares (4,000 preferred and 8,000 deferred), to carry on the business of engineers. Registered office : 39, Victoria Street, Westminster.

Hoylake and West Kirby Munitions Factory, Limited.—Capital £100 in £1 shares, to acquire a lease of premises at Station Road, Hoylake, and to carry on the business of munition manufacturers, founders, etc.

J. Lord, Limited.—Capital £2,000, in £1 shares, to carry on at Manchester, Birmingham, or elsewhere the business of makers of and dealers in furnaces and materials required therefor, etc. The first directors are J. Lord and Mrs. E. Lord. Registered office : 40, St. Peter's Gate, Stockport.

H. Burton & Company, Limited.—Capital, £2,000, in £1 shares, to carry on the business of brassfounders, etc., and to acquire the business of H. Burton & Company, at 90, Cannon Street, London, E.C. The first directors are G. E. Seymour and H. M. Burton. Registered office :—90, Cannon Street, London, E.C.

David Ashton & Company, Limited.—Capital £20,000, in £1 shares (5,000 6 per cent. non-cumulative preference), to acquire the business formerly carried on by C. Davenport and T. C. Goode at the Aztec Works, Neepsend, Sheffield, as David Ashton & Company, and to carry on the business of founders, forgemen, etc.

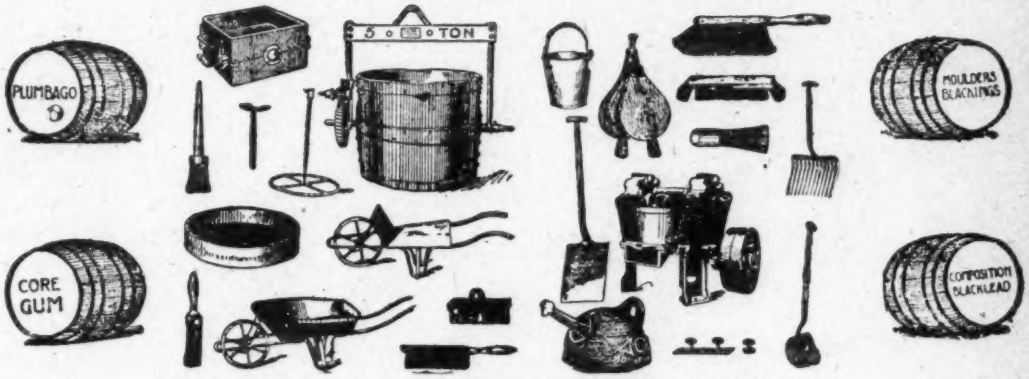
Wellington Foundries, Limited.—Capital £10,000, in £10 shares, to take over the business of iron and brass founders and engineers, carried on at the Wellington Foundry, Greenfield Street, Swansea, and at Dunvant, Glam., and to adopt an agreement with C. Gustavus and others. The first directors are C. Gustavus, F. E. Finlayson, E. Evans, and C. B. Jenkins.

Sutton & Ash, Limited.—Capital, £25,000, in £1 shares, (12,900 preferred, 8,600 ordinary, and 3,500 to be issued as ordinary, preferred, or deferred), to take over the business of metal brokers and merchants, and factors of iron and steel bars and other metal goods, etc., carried on by the executors of Thomas Cumberland (deceased), and H. W. Bainbridge, and H. Cumberland, at Snow Hill, Birmingham, and elsewhere, as Sutton and Ash, and to adopt an agreement with T. Cumberland, H. Cumberland, and H. W. Bainbridge. The first directors are H. W. Bainbridge (chairman) and H. Cumberland (both permanent), A. F. Hirst, and W. D. Lloyd.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



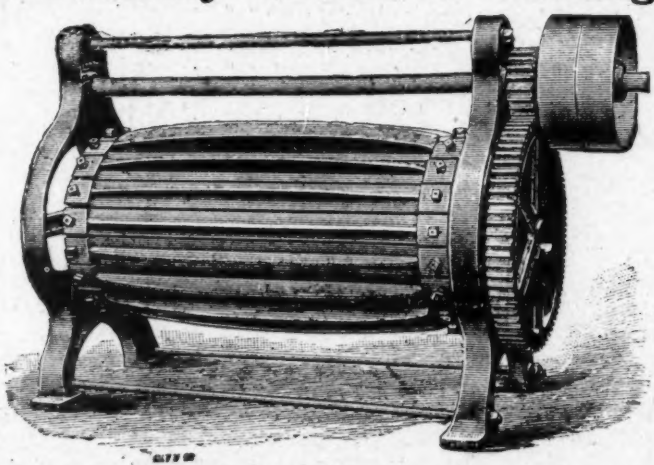
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

Cleveland.

	s.	d.
Cleveland No. 1	98	0
,, No 3	94	6
,, No. 4 foundry	93	6
,, No 4 forge	92	6
,, Mottled	—	
,, White	—	
East Coast hematite, mixed Nos. ..	140	0
Cleveland warrants	94	3

Above prices are for early f.o.b. deliveries and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers' cash prices.

Scotland.

	s.	d.
Standard Foundry (Glasgow Market settlement price)	85	0
Warrants, ditto	99	9

Makers' prices :—

	s.	d.		s.	d.
Gartsherrie	No. 1	118	6 No. 3	111	0
Coltness	No. 1	139	0 No. 3	111	0
Summerlee	No. 1	115	0 No. 3	110	0
Langloan	No. 1	115	0 No. 3	110	0
Calder	No. 1	112	6 No. 3	107	6
Clyde	No. 1	112	6 No. 3	107	6
Carnbroe	No. 1	112	6 No. 3	107	6
Monkland	No. 1	105	0 No. 3	103	6
Shotts	No. 1	110	6 No. 3	105	0
Govan	No. 1	105	0 No. 3	103	6

(All deliverable alongside Glasgow.)

Glengarnock	No. 1	115	0 No. 3	110	0

(Deliverable alongside Ardrossan.)

Dalmellington	No. 1	111	0 No. 3	109	0
Eglington	No. 1	111	0 No. 3	109	0

(Deliverable alongside Ayr.)

Carron	No. 1	—	No. 3	—	

(F.a.s. Grangemouth.)

Scotch hematite, f.o.t. steelworks 137 6

Lancashire.

	s.	d.	s.	d.
Lancashire No. 3 foundry f.o.t.	—		—	
Lincolnshire No. 3 foundry ..	—		—	
Derbyshire No. 3 foundry ..	91	0	94	0
Staffordshire No. 3 foundry	92	0	93	0
Cleveland No. 3 foundry	101	2	101	8

(All delivered equal Manchester.)

Scotch No. 3	Gartsherrie ..	—	—	
	Glengarnock ..	—	120	0
	Eglington ..	—	—	
	Summerlee ..	—	120	0

(Delivered Manchester Docks.)

North-West of England.

	s.	d.	s.	d.
Bessemer mixed numbers net f.o.b.	—		127	6
Hematite warrants net cash ..	—		115	0
Lorn cold-blast charcoal iron	—		—	

The Midlands.

		s.	d.	s.	d.
Staffs.	Part Mine forge ..	87	6	90	0
	Best All Mine ..	—		140	0
	Cold Blast ..	—		160	0

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

Northampton foundry ..	—		87	6
North Staffs. foundry ..	—		—	
Derby foundry	86	6	89	0
Nottinghamshire foundry ..	—		—	
Leicestershire foundry ..	—		89	0
Shropshire Cold-Blast ..	—		160	0

(Delivered South Staffordshire Works, net cash monthly.)

Lincolnshire.

	s.	d.	s.	d.
Forge	—		86	6
Grey forge	—		86	6
Basic	—		—	
No. 3 foundry	88	0	89	0
No. 4 foundry	—		—	

F.o.t. Makers' Works.

South Wales.

	s.	d.	s.	d.
Welsh Hematite	142	6	145	0

Ferro-Alloys.

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton	35	0	0
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	29	10	0
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit. Per ton	28	0	0
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	86	0	0
Ferro-vanadium : 33/40% Va., perlb. of Va. contained in the alloy ..	0	14	0
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton	27	10	0
Ferro-titanium : 23/25%, per pound carbonless	0	1	9
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained ..	0	18	0
Ferro-phosphorus : 20/25%. Per ton	16	10	0
*Ferro-manganese 80%	25	0	0
,, export	—		

* F.o.b. Liverpool.

Iron Castings.

Cleveland.

	£	s.	d.	£	s.	d.
Columns (plain) ..	—			to	—	
Pipes, 1¼ to 2½ in. ..	—				—	
,, 3 to 4 in. ..	—				—	
,, 5 to 8 in. ..	—				—	
,, 10 to 16 in. ..	—				—	
,, 18 to 24 in. ..	—				—	
Chairs	—				—	
Floor plates (open sand)	—				—	

(At work.)

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash ..	104	0	0	104	5	0
Three months ..	103	0	0	103	5	0
Electrolytic ..	132	0	0	136	0	0
Tough	122	0	0	123	0	0
Best selected ..	123	0	0	125	0	0

Tin.

	£	s.	d.	£	s.	d.
Standard, Cash ..	179	10	0	179	15	0
,, Three months	179	5	0	179	10	0
English Ingots	—			181	5	0
Bars	—			182	5	0
Refined	—			184	10	0

Spelter.

American	—	92	0	0
Specials	—	—		
Hard	—	67	10	0
British	—	94	0	0

Lead.

Soft Foreign	—	32	5	0
English	—	32	10	0

Antimony.

Regulus	—	95	0	0

Aluminium.

Virgin Metal 98/99% per ton	155	0	0	200	0	0

*Chromium (Metallic).

98/99% purity, per lb.	—		—

*Nickel.

In cubes, 98/99% purity Per ton	220	0	0			

*Tungsten Metal Powder.

96/98% purity .. per lb. ..	0	5	10

*Molybdenum Metal.

96/98% purity .. per lb. ..			—

*Cobalt Metal.

97% purity .. per lb. ..	0	8	0

Quicksilver.

75 lb. bottle	16	13.	9

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting ..	90	0	to 92	6
Iron scrap cast (cupola metal)	67	6	70	0

London (f.o.b.).

Heavy steel	80	0	
Light ,, ...	50	0	
Heavy cast	60	0	

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	105	0	0
Hy. Selected Scrap Brass ..	72	0	0
Hy. Tinned Copper Wire ..	92	0	0
Best Selected Gunmetal Scrap ..	84	0	0

Re-melted Ingot Lead 40s. under English Lead price on date of order.

Stocks.

Pig-Iron in Public Store.

	Feb. 9. Tons.	Inc. + or Dec. – since Feb. 10 1915. Tons.
Connal's at Glasgow Scotch	1,000	No change.
Ditto other makes ..	—	No change.
Connal's at Middlesbrough	91,526	– 28,438
Connal's at Middlesbrough hematite ..	—	No change.
West Coast hematite	2,016	– 1,946

Metals.

Copper, Europe and afloat	22,646	– 12,479
Tin, London, Holland, U.S.A. and afloat	17,468	+ 787

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	—		29	0
Foundry Coke	—		41	0
Furnace Coke	—		31	0

Newcastle-on-Tyne.

	F.o.b. s.	d.	Dunston. s.	d.
FOUNDRY COKE—				
Original Garesfield ..	40	0	42	0
Mickley	40	0	42	0
Stella Garesfield	40	0	42	0
Priestman's Garesfield ..	40	0	42	0
Consett Garesfield ..	40	0	42	0
Newcastle gas coke ..	—		29	0

Cardiff.

	s.	d.	s.	d.
Special Foundry Coke ..	45	0	to 47	6
Foundry Coke	42	0	to 44	0
Furnace Coke	33	0	to 37	0

Leeds.

Furnace Coke (washed) ..	—	24	0

Birmingham.

Foundry Coke	—		—
Furnace Coke	—		—
Gas Coke	25	0	27 6

Glasgow.

Foundry Coke	—	35	6
Furnace Coke	—	32	6
Gas Coke	—	—	

London.

Welsh or Durham Foundry, d/d London Stations, in truck	47	6	48	6
Ditto, d/d Birmingham Stations	43	0	43	6
Yorkshire, d/d London Stations, in truck ..	—		32	6
Ditto, d/d Birmingham Stations	—		30	0

SITUATIONS VACANT AND WANTED.

FOREMAN, with special experience in loam, for London iron-foundry engaged on Government work. Must be thoroughly experienced. No one already on Government work need apply.—Write, stating age, experience and salary required, to your nearest Labour Exchange, mentioning this paper and No. A1314.

FOR SALE AND WANTED.

GANISTER for Cupolas, Furnaces, etc. Very best quality. On War Office List. Supplied to all leading Iron Works and Foundries. Established 30 years.—Astbury Silica Company, Newbold, Astbury, near Congleton (late Sankey & Hall). Communications to D. Boulton, Astbury Silica Company, Kidsgrove, Stoke-on-Trent.

STEAM HAMMER, self-contained, 5¼-in. cylinder, 14-in. stroke, by Woodhead; belt-driven power hammers, friction clutch, 60 lbs. blow, self-contained. —WIDDOWSON'S, Canal Street, Nottingham.

PATTERNS made by experienced men with up-to-date machinery; prompt delivery; estimates free.—Send your drawings to E. Cooke, 61-63, High Street, Hanley, Staffs.

5-TON Hand Swing Jib Crane, 17-ft. radius, 20-ft. high, with double-geared crab chains and return blocks racking in-and-out motion, top fixing and foot step chains, recently tested to 5½ tons.—C. F. DAVIS, 18, Billiter Buildings, London, E.C.

ADVERTISER requires Quotations from Manufacturers of Foundry Requisites and General Mill Furnishing; good connection with engineers and ironfounders.—Apply, Box 597, Offices of FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

BRASS, Gun-metal, Aluminium and Steel Specialities. Manufactured or Fittings supplied; also Smith's Work of every description. Enquiries invited — METAL WORKS, 8-10, Hawerside Street, Southport.

FOR SALE.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

SANKEY
FOUNDRY LADLES
Pressed Steel
Joseph Sankey & Sons Ltd
Hadley · · · · · Salop

PATTERN SHOP SUPPLIES.

Wires: "Requisites, B'ham." J. BURN & CO., 'Phone: 137 Victoria.
Henshaw Road, Small Heath, BIRMINGHAM.

ARE YOU INTERESTED IN THE PRODUCTION OF CHEAP, ACCURATE CASTINGS?

We Specialise in :: MOULDING MACHINES, PATTERN PLATES, MOULDING BOXES, SNAP FLASKS, etc. :: ::

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One ditto, with high-speed Vertical Engine combined.
Thwaites' Roots Blower, 11½" discharge.
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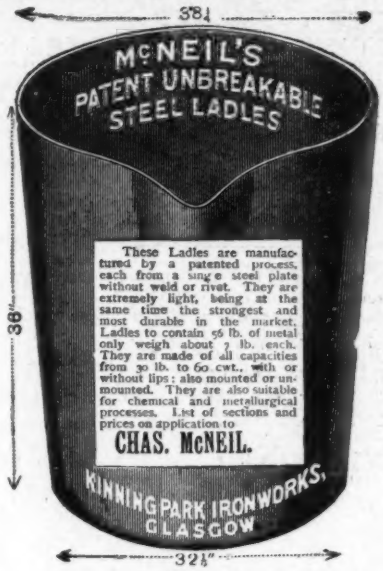
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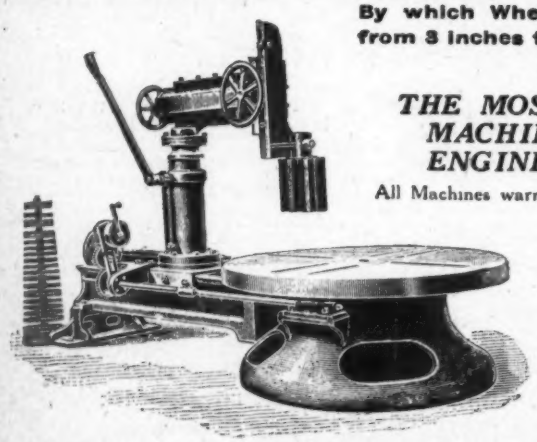

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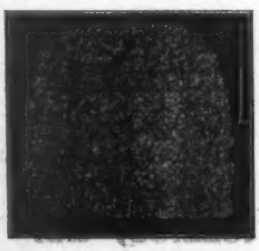

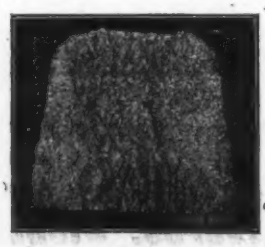

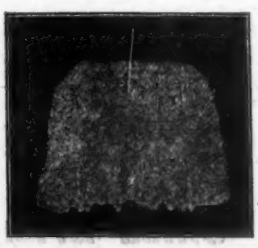

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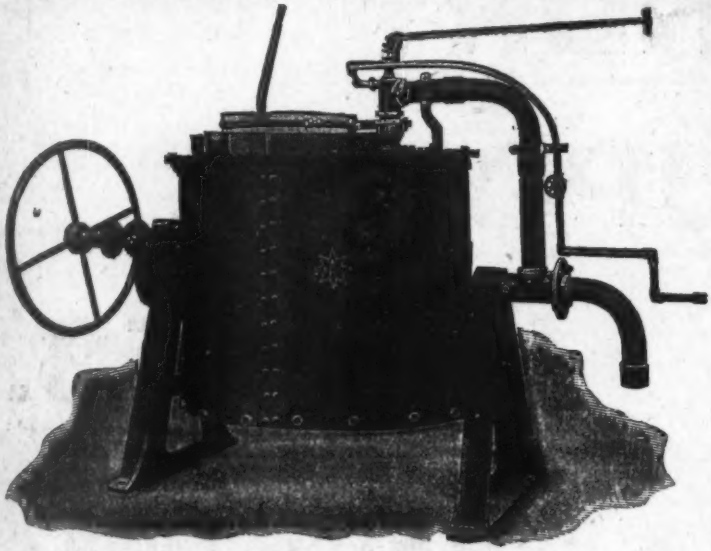

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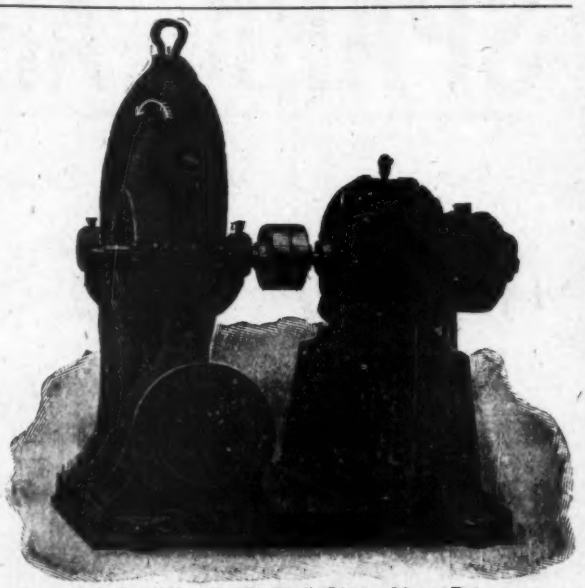

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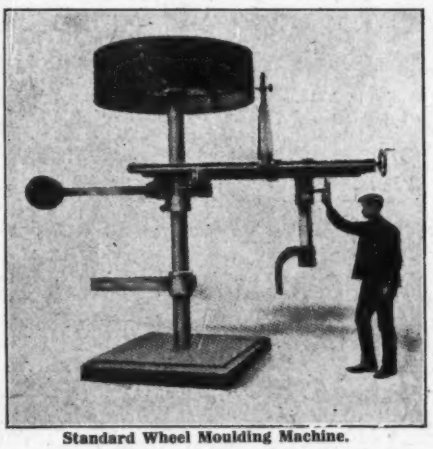

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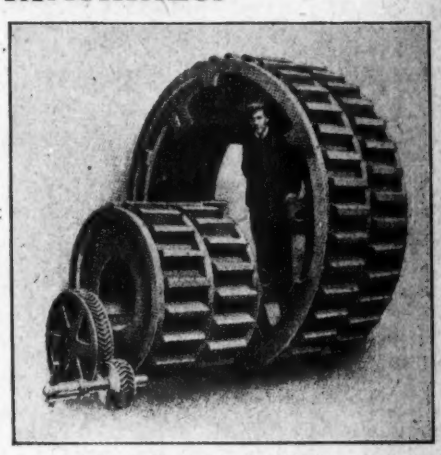

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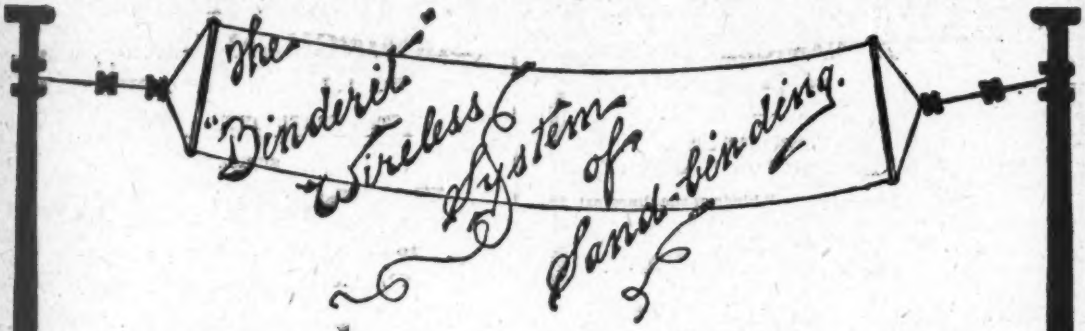

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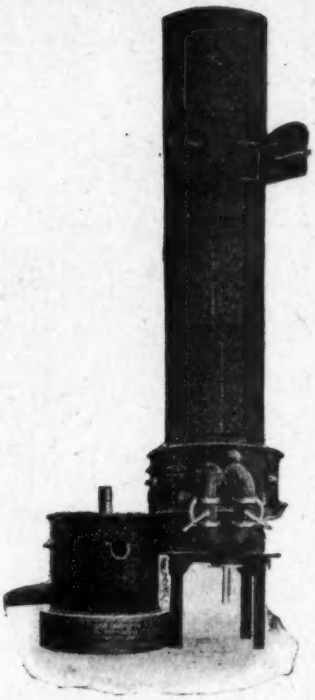

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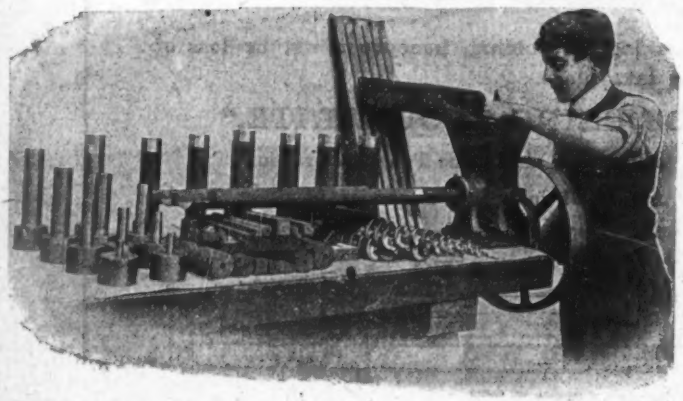

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(2 feet of core in 15 seconds with the labour of an unskilled youth).
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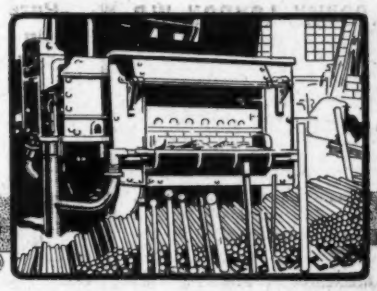

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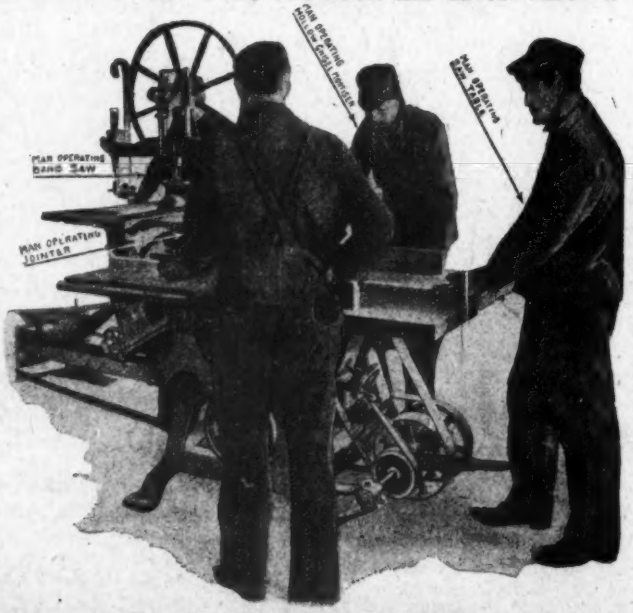

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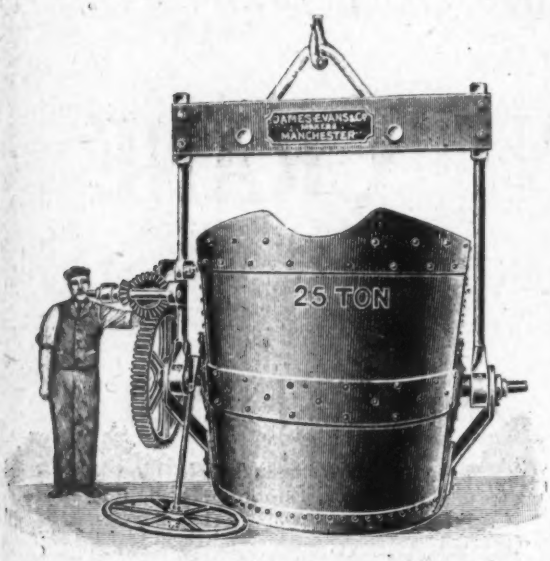

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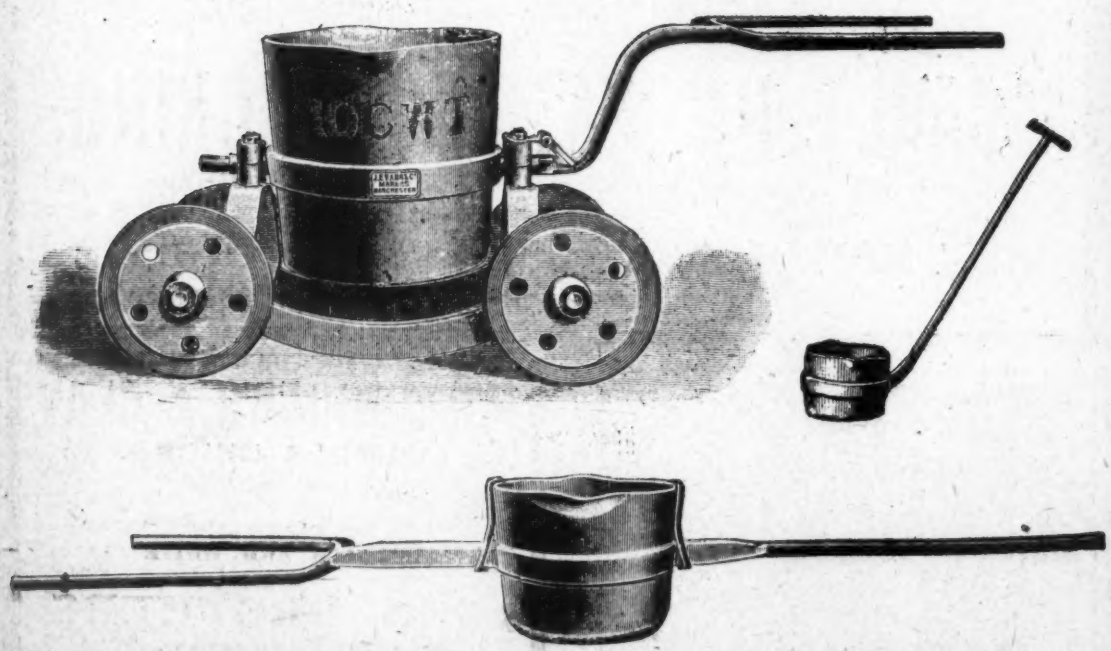

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